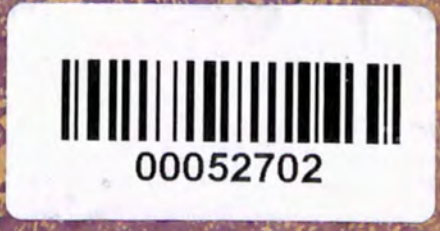
598·11
Bai Des
52702



THE
ASIATIC SOCIETY OF BOMBAY
Town Hall, Bombay.

Digitized with financial assistance from the
Government of Maharashtra
on 13 February, 2016

518.11
Rai/Dev
52702

[From the Proceedings of the Academy of Natural Sciences of Philadelphia, December, 1858.]

Description of New Genera and Species of North American Lizards in the Museum of the Smithsonian Institution.

BY SPENCER F. BAIRD.

Family IGUANIDÆ.

EUPHRYNE, Baird.—Body very heavy and clumsy. Tail shorter than the body; very thick and conical. Scales very small, but imbricated and angular throughout. A median dorsal band of about 20 rows, and a largepatch on the sides of scales larger than the rest. Infra-orbitals in a series of small, nearly equal plates. Supra-cephalic plates all small, least on the outer part of the supra-orbital region. Upper labials rectangular, not imbricated. Posterior molars with five cusps; palate toothed. Claws very thick and stout, anterior much the longer.

Euphryne obesus, Baird.—Width of head nearly equal to distance from nose to ear. Tail shorter than the body. General color of the young, olive green, with five broad transverse bars above from head to base of tail, and about as many on the tail; these rings yellow, dotted with red. Beneath pea green dotted with black. With increasing age, the bands become obsolete and disappear, the general color becoming reddish olive.

The largest and heaviest of American *Iguanidæ*, sometimes exceeding a foot in length. Abundant in the canons of the Colorado, of California, collected by Maj. Thomas, Mex. Boundary Survey, and Lt. Ives' Expedition. Type No. 4172

Crotaphytus reticulatus, Baird.—Infra-orbital chain in a series of 6 or 8 nearly equal plates. Scales on the gular fold much smaller than those between the fore legs. Above ashy gray, with a hexagonal reticulation of lighter, the interstices here and there dark brown. Chin and throat reticulated. Neither black collar nor light spots. More closely related to *Crotaphytus collaris*, than to *Crotaphytus* (*Gambelia*) *wislizenii*.

Hab.—Laredo and Ringgold Barracks, Tex. Mex. Boundary Survey. J. H. Clark and A. Schott. Type 2692.

Uta symmetrica, Baird.—Larger dorsal scales in four regular series, two on either side of the median smaller ones. Head short, [illegible], one and a half times as wide as deep. Tail one and a half times the [illegible] body. General color light brown above, the belly white. Sides with [illegible] transverse bands of blackish. Size of *U. ornata*.

Hab.—Fort Yuma, Cal. Mex. Boundary Survey. A. Schott. Type No. 2760.

Uta schottii, Baird.—Dorsal scales and size as in the last. Head pointed, narrow, nearly or quite as high as wide. General color nearly black, scarcely lighter beneath. Back with small blue spots. Tail banded laterally with the same.

Hab.—Sta. Madelina, Cal. Mex. Boundary Survey. A. Schott. Type No. 2761.

UMA, Baird.—Ears distinct. A very long infra-orbital plate. Palate without teeth. Outer face of upper labials plane and broadly vertical; the labials themselves much imbricated, and very oblique. Scales of body above equal, much smaller than ventral ones. Inter-orbital space with two series of plates. Claws very long, slender and straight. Sides with a round black spot. Tail? (broken off.)

Uma notata, Baird.—Head about two-fifths the head and body. Above light pea green, spotted with darker green. Beneath white. Head and body about two inches long.

Hab.—Mohave Desert. Lt. Williamson, Dr. A. L. Heermann. Type No. 4124.

Holbrookia approximans, Baird.—Similar in size and general character to *H. maculata*. Tail shorter than body. Two small vertical indigo black patches on the side of belly, entirely visible from below; with a light blue areola.

b 2358 BBi 28 52702

Central point of belly about opposite the middle point between the two patchse. No light stripe on side of neck. Upper parts and sides gray, sprinkled with whitish. Head broad, very convex above. Hind foot about one-third the head and body.

Hab.—Lower Rio Grande. Mex. Boundary Survey, and Lt. Couch.

Sceloporus floridanus, Baird.—Cephalic plates smooth. Three series of supra-orbitals, a broad central one, and an external and internal of very small plates. Scales large, rough. 33 oblique rows of dorsal scales from head to anns. Scales on inside of tibia carinated. Free portion of longest hind toe exceeding the cephalic plates. Color above greenish yellow, with two broad yellow stripes, five scales apart. Back with distinct transverse blackish bars. Larger than *S. undulatus*.

Hab.—Pensacola, Fla. Dr. Jeffries, U. S. N. Type No. 2874.

Sceloporus ornatus, Baird.—Dorsal scales in about 64 oblique series, with but slight carination, mucronation and denticulation. Femoral pores 12. A well marked black cervical collar, complete above, and margined with yellowish. Color dark green above, nearly black towards the median line. Back with small yellowish spots.

Hab.—Patos, Coahuila, Lt. Couch. Type No. 2845.

Sceloporus longipes, Baird.—Similar to *S. occidentalis*, in general characters of shape, coloration and smoothness of the scales on inside of tibia. Limbs and tail much lengthened. Free portion of hind toe longer than the cephalic plates. The hind leg as long as the body and neck. Hind foot contained about two and a half times in the head and body.

Hab.—Fort Tejon, Cal. John Xantus. Type No. 4358.

Sceloporus couchii, Baird.—General appearance of *S. marmoratus*, Hall. Cephalic plates smooth. Scales very small. About 80 oblique dorsal rows from head to tail. Femoral pores 25. Color above dark green, with two lateral light stripes, separated by 18 rows of scales. Back with irregular spots. Sides with a white band from groin. An obsolete dark indigo patch on each side the belly, widely separated below. Sides of jaw banded transversely with blue and whitish. A subcircular indigo patch in front of shoulder, surrounded by light blotches.

Hab.—Santa Catarina, N. Leon. Lt. Couch. Type No. 2739.

Anolis cooperi, Baird.—Cephalic plates smooth. Inter-orbital ridges running to the side of the rostrum, posterior to the nostrils which are rather lateral. Digital pallets inconspicuous. A few central dorsal rows of scales abruptly larger than the rest, but the lateral all much smaller than the ventral. General color grayish above. Less than *A. carolinensis*.

Hab.—California. Dr. J. G. Cooper. Type No. 4165.

Family GECKOTIDÆ.

Sphæriodactylus notatus, Baird.—Scales on back and sides large, equal, strongly carinated; those on belly smaller, smooth, hexagonal. Above light brownish yellow, uniformly dotted above with reddish brown, most distinct on the head, least so on the belly.

Hab.—Key West, Fla., Prof. Agassiz and Prof. W. H. B. Thomas. Type No. 3215.

Stenodactylus variegatus, Baird.—Head very broad. Hind foot contained six times in head and body. Above brownish yellow, with irregular small blotches of light reddish brown, sometimes in broad transverse bands. Edges of eyelids and whole under surface opaque white.

Hab.—Rio Grande and Gila Valleys. Mex. Boundary Survey. A. Schott. Type 3217.

Family XANTUSIDÆ.

General form lacertian. No crests nor spines. Head with very large,

polygonal plates. Scales of back small, granular; those of belly large, square, in transverse series. Tongue broad, linear, not retractile, firmly attached except at tip, which is only slightly notched, the base not emarginate. Surface of tongue with a series of oblique converging ridges on each side. Teeth simple, pleurodont. Digits with one series of transverse smooth lamellæ beneath.

XANTUSIA, Baird.—Body slender; cylindrical. Femoral pores. Three folds on the throat, the anterior connecting the ears inferiorly and encircling the head. Pupil vertical. No eyelids.

Xantusia vigilis, Baird.—Hind leg extended forwards, reaches the first gular fold, and is contained about 2¾ times in head and body. Claws small. Color above dark brownish yellow, varied with blackish spots on single tubercles. Young vermiculated with yellowish on a brown ground. A yellowish line on each side of the neck, with two others on the nape, making four parallel ones. Under parts whitish. Head and body about two inches long.

Hab.—Fort Tejon, Cal. John Xantus. Type No. 3063.

Family LACERTIDÆ.

Cnemidophorus inornatus, Baird.—Scales on the gular fold, smaller than those on the breast anteriorly, and scarcely larger than those on the middle of the chin. Scales of back tubercular and elevated. Hind feet about two-fifths the head and body. General color light greenish olive, paler beneath. No lines on the body.

Hab.—New Leon. Lt. Couch. Type No. 3032.

Cnemidophorus octolineatus, Baird.—Gular fold as in the last. Hind foot not two-fifths the head and body. Scales of back depressed. General color light greenish olive, paler beneath. Back with eight equidistant and approximated light lines.

Hab.—New Leon. Lt. Couch. Type No. 3009.

Family ZONURIDÆ.

Gerrhonotus webbii, Baird.—Tail 2½ times the head and body. Scales strongly carinated. Dorsal scales in 48 transverse rows. Body encircled by 26 rows of scales, of which 12 are ventral. Hind feet longer than from snout to ear. Above leaden olivaceous brown, lighter beneath. Back with ten or twelve blackish bars, bordered in front by brownish or reddish yellow.

Hab.—Near San Diego, Cal. Dr. Webb. Type No. 3078.

Gerrhonotus infernalis, Baird.—Dorsal scales carinated in 16 longitudinal rows; ventral in 12. Nasal plate in contact with the 2d labial only. Tail twice as long as head and body. 51 transverse rows of scales from head to tail. Color clear light olive, with 8 cross bars of dusky. Beneath yellowish, marbled faintly with dull olive. Head plain.

Hab.—Devil's River, Tex. Mex. Boundary Survey. Dr. Kennerly. Type No. 3090.

Gerrhonotus olivaceus, Baird.—No single frontal. A series of three pairs of plates between the vertical and rostral, becoming successively smaller. Two post-nasals; one loral. 39 transverse rows of scales on back from head to tail. 12 longitudinal rows above; the 6 central, strongly carinated. Color dark olive green, with a series of faint dusky bars. Beneath greenish white.

Hab.—Near San Diego. Mex. Boundary Survey. A. Schott. Type No. 3096.

Lepidosternon floridanum, Baird.—Body as thick as a large goose quill. No limbs. A large pentagonal plate on the head above, encircled by nine others, the rostrum ending in a broad horizontal crescent, overhanging the mouth. No ears nor visible eyes. Tail contained 18 times in the body, much depressed, its upper surface with large tubercles. Color white in alcohol.

Hab.—Micanopy, Florida. Dr. J. B. Barratt. Type No. 3202.

Family SCINCIDÆ.

Plestiodon leptogrammus, Baird.—Two post-nasals, the posterior one behind and above the much smaller anterior. Color black, with five narrow, white lines, the two lateral along the middle of single rows. Median light line not bifurcated.

Hab.—Platte River Valley. Lt. Warren, Dr. Hayden. Type No. 3119.

Plestiodon inornatus, Baird.—Two post-nasals of equal size, one above the other. Hind leg applied three times forwards, reaching the ear.

Hab.—Sand Hills of Platte. Lt. Warren, Dr. Hayden. Type No. 3110.

Plestiodon tetragrammus, Baird.—One post-nasal plate; post-frontal and inter-nasals separated by the post-nasal. Five supra-orbitals. Dorsal scales of equal width. Light olive green above; sides with two yellowish lines, separated by six rows of darker olive scales. Upper labials pure yellowish. Body encircled by about 28 rows of scales. No dorsal stripe.

Hab—Lower Rio Grande. Dr. Berlandier, Lt. Couch. Type No. 3124.

Plestiodon egregius, Baird.—One post-nasal plate; post-frontal and inter-nasals separated by the post-nasal. Four upper labials. Ears very small. Two central dorsal rows largest. Body cylindrical. Color reddish ash, with two or three white lines on each side, margined with dusky, sometimes a third; all these along the centres of single rows of scales. Upper lateral lines separated by two plain rows. Body encircled by about 22 rows of scales.

Hab.—Indian Key, Fla. G. Wurdemann. Type No. 3128.

Plestiodon septentrionalis, Baird.—One post-nasal plate which does not separate the inter-nasals and post-frontals. Color above olive, with four equidistant and equal dark stripes on adjacent half rows of scales. Two narrow white lines on each side, traversing the centres of single rows, and margined above and below by black. Upper lateral light stripes separated by six rows of scales. Beneath light greenish.

Hab.—Minnesota and Nebraska. Rev. S. W. Manney. Type 1356.

[From the Proceedings of the Academy of Natural Sciences of Philadelphia, March, 1859.]

Notes on COLUBER CALLIGASTER of Say, and a description of new species of Serpents in the collection of the North Western University of Evanston, Ill.*

BY R. KENNICOTT.

Eutænia Sackenii Kennicott.

Sp. ch.—Very slender; tail forming one third of the total length. Crown more elevated and convex anteriorly than in *E. saurita*. Nineteen dorsal rows of scales. Color olive black above, not lighter below the lateral stripe. Lateral stripe greenish yellow, very narrow on the third and fourth lateral rows. No dorsal stripe. Abdomen uniform greenish.

In form, this closely resembles *E. saurita*, but is at once distinguished by the absence of the dorsal stripe, of which there is no trace, except for about a half inch behind the head. The color of the upper parts is also much darker, and the first two rows of scales below the dorsal stripe are not lighter than above it. Florida.—Baron Osten Sacken.

Scotophis calligaster.

Coluber calligaster Say, in Long's Exped.

Sp. ch.—Head very narrow, elongated, much wider behind; nose very obtuse, the whole outline subquadrangular; much elevated anteriorly, as high as wide before the eyes, flattened and rather depressed on the occiput. Eye large. Vertical plate narrow, much longer than wide, tapering but little behind. Superciliaries very narrow. Postfrontals and loral large. Twenty-seven dorsal rows of scales, only the central carinated, and these very faintly. Ground color olivaceous white; a dorsal series of transverse brown blotches separated by narrower intervals than in *S. Emoryi*, B. & G., with two smaller series on each side. Temporal light stripe, narrower than in *S. Emoryi*. A brown blotch under the eye, and another on the second and third upper labials. Labials not margined with black.

This is very closely allied to *S. Emoryi*, from which it differs in having the head narrower posteriorly, with a more obtuse snout, smaller vertical, narrower superciliaries, larger loral, narrower intervals between the dorsal blotches, which are themselves less rounded, narrower light temporal stripe, etc. From *S. guttatus*, it may be readily distinguished by the color, transverse dorsal blotches, etc.; and from the other species of the genus it differs in much the same points with *S. Emoryi*. There can be no hesitation in referring this species to the *Coluber calligaster* of Say. The very faint carinations of the central dorsal scales might easily be overlooked. Like *S. Emoryi*, it bears a strong general resemblance to *Ophibolus eximius*, to which species Say's description has been referred by Dr. Holbrook, and others; but from this and *O. Evansii*, it may at once be distinguished by the large eye, elongated head, divided postabdominal scutella, carinated scales, and other generic characters.

Hyatt, Anderson Co., Kansas, Mr. Samuel Arny.

Ophibolus Evansii Kennicott.

Ophibolus Evansii Kennicott, Rep. of Mex. Boundary Survey.

Sp. ch.—Light olivaceous brown or gray, with a dorsal series of about sixty subquadrangular emarginate dark chestnut brown blotches from head to tip of

* Specimens of these species are also in the Museum of the Smithsonian Institution, Washington.

tail, and two smaller lateral series on each side. Dorsal scales in twenty-five rows.

This is most nearly allied to *O. eximius*, but differs strikingly in the number of dorsal rows of scales,—twenty-five instead of twenty-one; also in having a more elongated, narrow and elevated head, narrower snout, anterior and posterior emarginations in the dorsal blotches, etc.

Prairies of Central Illinois, S. H. Roots, C. Mills, S. W. Arnold.

The species is dedicated to Prof. J. Evans, to whose interest in the investigation of the zoology of the north west, the N. W. University is principally indebted for the large collections of animals made under its auspices.

DIADOPHIS ARNYI Kennicott.

Sp. ch.—Form slender, though less so than in *D. docilis*. Body above uniform leaden black, the crown scarcely darker; abdomen yellow, thickly and irregularly spotted with black, the spots more numerous than in *D. docilis*, and extending to some distance behind the anus; head beneath thickly mottled with black spots of much smaller size than those on the abdomen. A narrow light yellow occipital ring, one to one and a half scales wide. Dorsal scales in seventeen rows.

Resembles *D. docilis*, from which it will be distinguished by the color, shorter body, narrower head, spots under the tail, and narrower occipital ring; from *D. regalis* by its occipital ring, and from the other species by the number of dorsal rows.

Hyatt, Anderson Co., Kansas.—Samuel Arny.

VIRGINIA ELEGANS Kennicott.

Sp. ch.—Resembles *V. valeriæ*; vertical and occipital plates narrower. Dorsal scales very narrow and elongated, much more so than in *V. valeriæ*, disposed in 17 rows. Color uniform light olivaceous brown above; dull yellowish-white beneath.

Readily distinguished from the nearly allied *V. valeriæ* by the narrower dorsal scales in 17 rows instead of 15 as in that species.

Heavily timbered regions of southern Illinois.—Dr. Hugh McVean, J. W. Waugh.

CELUTA VERMIS Kennicott.

Sp. ch.—Larger than *C. amœna* and *C. Helenæ*. Two pairs of frontal plates. Color above lustrous purplish black, much darker than in *C. amœna*. Abdomen pale yellowish flesh color, (probably brighter in life); this color extending to the third latera row of dorsal scales.

Though possessing the general form of *C. amœna*, this differs strikingly in the larger size, darker color of the upper parts, and the extension of the flesh color of the abdomen over to the third lateral row of scales; in *C. amœna* this color extends only to the second row.

Missouri,—Dr. P. R. Hoy.

CELUTA HELENÆ Kennicott.

Sp. ch.—Snout shorter and narrower than in *C. amœna*. A single pair of frontal plates. Color above lustrous chestnut brown; beneath pale yellowish, (flesh color in life) color of the abdomen extending to second lateral row of dorsal scales.

Readily distinguishable by the suppression of the anterior frontals.

Monticello, Miss., Miss Helen Tennison; Southern Illinois (abundant in the woods), Dr. H. McVean, Robt. Gow, C. Thomas, L. W. Ashley.

[From the Proceedings of the Academy of Natural Sciences, June, 1856.]

Contributions to the Ichthyology of the Western Coast of the United States, from specimens in the museum of the Smithsonian Institution.

By CHARLES GIRARD, M. D.

Two years have scarcely elapsed since I communicated to the Academy descriptions of various fishes collected upon different points of the Pacific coast of North America. During that period the indefatigable researches of several officers of the U. S. Army, and naturalists attached to the surveys made under orders from the General Government, have brought to light many new and interesting members of that class of animals, and of which I propose now to give a brief account, extracted from final Reports, made to the officers in charge of these surveys.

It has also been deemed advisable to mention such changes as have been made in the generic position of several species previously described, either by me or others, in order to give a more correct idea of the Reports just alluded to.

It will be remembered that while I was engaged in those investigations of our Western fishes, two naturalists, Drs. W. O. Ayers and W. P. Gibbons, both residents of San Francisco, Cal., had (without any knowledge of what I was doing,) described a certain number of species, some of which we already know have proved identical with my own. The law of priority in their publication will decide upon the names to be finally adopted in the nomenclature. So far I have been unwilling to settle upon any identifications without the specimens to go by, in order to avoid confusion as well as complicate the synonymy. Drs. Ayres and Gibbons, both, have shown an earnest desire to furnish me with authentic specimens of the species which they have described, and I am happy to say that from the former I have been favored by a good many up to this day, as will be seen further on.

For reference to the species described by Prof. Agassiz, some of which have appeared in my papers, it is but just to say that such identifications as were attempted by me, were made from the accounts published at that time. As far as genera are concerned I feel confident that no error was committed; in regard to the species I entertain certain doubts which can not be removed by the documents at our command. I have sought to do justice to the subject from the very beginning, and rather than introduce any changes in their present nomenclature I send them before the world as they now stand.

With the above preliminaries I proceed into the subject.

The species formerly described by me under the genus *Labrax* were found, upon further examination, to constitute a genus by itself, the relationship of which being more those of *Serranus* than of *Labrax*, and it is in the vicinity of the former that it ought to be placed in the ichthyic method. From *Serranus* it may be distinguished by the outline of the spinous dorsal fin, and the relative development of the canine teeth, which are so small as to have suggested the idea that the species belonged to *Labrax*.

The new genus we will henceforth call

PARALABRAX,

and characterise as follow: "General physiognomy that of *Labrax*, but the first dorsal fin is contiguous to the second as in *Serranus*. The profil of the body is subfusiform, the caudal fin subtruncated or slightly emarginated posteriorly.

The head is subconical, the lower jaw a little longer than the upper, the mouth rather large; card-like teeth upon the premaxillaries, dentaries, vomer and palatines, with a row of small canine teeth along the edges of the jaws. Tongue smooth. Small and homogenous spines upon the outer curve of the preopercle. Two small and inconspicuous spines upon the margin of the opercle. Edge of suborbital, entire; humerus denticulated; opercular apparatus and cheeks covered with scales, smaller on the cheeks than on the opercles. Gill openings continuous under the throat; branchiostegal rays, six in number. Scales minutely serrated posteriorly."

PARALABRAX NEBULIFER and P. CLATHRATUS

are the two species.

Dr. Ayres's *Centrarchus maculosus* is my C. INTERRUPTUS.

A new and interesting member of the group *Trachinidæ*, we inscribe into the method under the appellation of

HOMALOPOMUS,

"The general aspect of which is elongated, the mouth large, the lower jaw longest; upper and lower jaws provided with canine teeth; card-like teeth on the vomer. Palatines toothless; tongue smooth. Dorsal fins separated; anterior, small and subtriangular; posterior, extending mostly to rest of space towards the caudal. Anal fin longer than deep, situated far back. Opercular apparatus spineless and scaly; cheeks smooth and scaleless. Upper surface of head covered with minute scales. Scales covering the body of moderate development with posterior margin entire, and smooth. Gill openings continuous under the head; branchiostegals, six in number."

A single species is known, several specimens of which were examined, all of which were collected at Astoria, Oregon Territory, by Lt. W. P. Trowbridge, U. S. A., to whom I take pleasure in dedicating it.

HOMALOPOMUS TROWBRIDGII

has the "snout pointed, the mouth deeply cleft, and the posterior extremity of the maxillaries extending to the vertical line of the posterior edge of the pupil. The eyes are large. The tips of the pectoral fins reach as far as the anterior margin of the anal fin. The color is greyish brown above, and silvery grey beneath."

In the Cottoid group there are glorious additions. In the first place I have had the great satisfaction of identifying, from actual specimens, the *Cottus asper* of Sir John Richardson, and to describe it comparatively with the other members of the same genus.

Amongst the truly marine representatives I will first introduce a type which seems to bear much closer affinities to the fresh water genera than was anticipated.

In naming it

OLIGOCOTTUS,

allusion is made chiefly to its diminutive size. We have full evidence that the specimens before us are adults, and consequently have not hesitated in the selection of that name. We are aware, however, that further search might bring to notice other species not quite so small, and still of the same generic stamp. On the other hand, the etymology of a name is of but little avail towards elucidating the history of the object it designates. The natural characters of the genus will read as follows: "Head smooth, with the exception of a few spines upon the preopercle and snout. Upper jaw slightly the longest. Teeth upon the premaxillaries, dentaries, front of vomer and palatines. Gill openings continuous under the throat; branchiostegals six. Dorsal fins contiguous. Caudal posteriorly rounded. Insertion of ventrals backwards the base of pectorals. Origin of anal fin in advance of the anterior margin of second dorsal. Skin smooth, lateral line continuous for the whole length of the body."

being the only species known at present, we will characterize it by saying: "that the mouth is moderately cleft; the posterior extremity of the maxillary extending to a vertical line intersecting the pupil. A stoutish bicuspid processus on the convexity of the preopercle. Two acute nasal spines. Anterior dorsal lower than the second or posterior. Yellowish brown above, mottled or variegated with blackish; along the dorsal region a series of blotches of a deeper hue; lower half of the sides vermiculated. Abdomen of a bright saffron or yellow hue in the male. Inferior surface of head with traces of black markings; throat and abdomen unicolor, as also the ventrals and anal. Dorsals, caudal, and pectorals transversally barred."

It has been observed on several points of the coast between the bay of San Francisco, Cal., to Puget Sound, W. T. In 1854, a few dried up specimens were taken near Presidio by Lt. W. P. Trowbridge, but their precarious state of keeping did not permit us to classify them. The same was the case with those collected at Fort Steilacoom by Dr. Geo. Suckley. It is but very recently that well preserved specimens, collected by E. Samuels, in Tomales Bay, Cal., having reached us, we have been prepared to determine their position in the ichthyic method.

The fish mentioned by Dr. Ayres under the name of *Acanthocottus inermis* proves to be my LEPTOCOTTUS ARMATUS.

Next in order is another and entirely new genus, for which the name of

LEIOCOTTUS,

has been selected, more particularly in reference to its smooth aspect. Its characters are: "head perfectly smooth; spines upon the preopercle only. Mouth moderately cleft: jaws equal. Teeth upon the premaxillaries, dentaries and front of the vomer; none on the palatines. Barbules upon the maxillaries. Gill openings continuous under the throat; branchiostegal rays five. Dorsals nearly contiguous upon their bases. Ventrals inserted backwards of the base of the pectorals. Caudal posteriorly subtruncated. Skin perfectly smooth, bearing neither prickles nor scales. Lateral line well marked and continuous from head to tail."

The species which has come under my observation has so much of the aspect of *Trigla* that the specific name of

LEIOCOTTUS HIRUNDO

suggested itself for it." The snout is declivous and rather pointed; the posterior extremity of the maxillary is provided with two or three barbules and reaches a vertical line drawn a little beyond the anterior rim of the orbit. Superior regions blackish brown; abdomen whitish beneath; inferior part of tail yellow."

It was collected by Lt. W. P. Trowbridge, U. S. A. at the island of San Miguel, Cal.

Dr. Ayres' *Hemitripterus marmoratus*, is my SCORPÆNICHTHYS MARMORATUS,

Clypeocottus robustus of the same author, is my ASPICOTTUS BISON.

The species described by me as *Scorpænichthys lateralis* was subsequently referred by Dr. Ayres to a new genus of his under the denomination of *Calycilepidotus lateralis*, together with another species at that time unknown to me, under the name of *C. spinosus*. On a former occasion Dr. Ayres had announced the presence of two species of hemilepidoti in the Bay of San Francisco, for which he proposed the names of *H. nebulosus* and *H. spinosus*. My *Scorpænichthys lateralis* was subsequently identified by himself to his *H. nebulosus*, and it was then that the genus *Calycilepidotus* appeared with two species: *C. spinosus* and C. *lateralis*.

C. spinosus I have carefully examined, and I am satisfied that its proper place is in the genus *Hemilepidotus*, as characterised by Cuvier. In order, however, to furnish reliable data to go upon, I must be permitted to offer a diagnosis of of that genus as it now stands.

HEMILEPIDOTUS.

"Head rough and prickly, with membranous flaps on various parts; opercular apparatus spinous. Mouth moderately cleft; jaws equal. Teeth upon the premaxillaries, dentaries, front of vomer and palatines. Gill openings separated beneath by an isthmus; branchiostegals, six on either side. Dorsal fins contiguous. Caudal rounded posteriorly. Insertion of ventrals opposite the base of pectorals. Longitudinal bands of scales alternating with nacked areas; scales themselves finely denticulated."

HEMILEPIDOTUS SPINOSUS

"has membranous flaps on the upper surface and sides of the head. The eyes are quite large. The posterior free extremity of the maxillary extends to a vertical line drawn at the posterior rim of the pupil. Dorsal band of scales composed of six rows or series; lateral band of seven, five below and two above the lateral line. Ground color dark reddish brown, with darker transverse bands and blotches."

Specimens labelled by Dr. Ayres were collected in the Bay of San Francisco, Cal., by Dr. John S. Newberry; others in Humboldt Bay, by Lt. W. P. Trowbridge, U. S. A.

So much for *Calycilepidotus spinosus*: it is a true Hemilepidotus.

As to *C. lateralis*, the second species of Dr. Ayres' genus, a careful study has convinced me that it is not specifically identical with my *Scorpænichthys lateralis*. Subsequent investigations of more perfect specimens have convinced me of the propriety of removing the latter from the genus Scorpænichthys, and since I had no specimens of *Hemilepidotus nebulosus*, Ayres, (*Calycilepidotus lateralis*, Ayres, non mihi) by which to determine its generic affinities, I have been compelled to institute, under the name of

ARTEDIUS,

a new genus to receive two species, the one above referred to, and formerly described by me as *Scorpænichthys lateralis*, and another which so far had remained unnoticed. The following are its characters: "Head rough, with supra-orbital membranous flaps. Spines upon the preopercle only. Mouth moderately cleft; lower jaw slightly overlapped by the upper. Teeth upon the premaxillaries, dentaries, front of vomer, and palatines. Gill openings continuous under the throat; branchiostegals five on either side. Dorsal fins separated. Caudal subtruncated posteriorly. Insertion of ventrals opposite the base of the pectorals. A dorsal band of pectinated scales."

ARTEDIUS LATERALIS.

Scorpænichthys lateralis, Grd., has the "surface of the head smooth. Preopercle armed with a flat bicuspid spine. Band of dorsal scales narrow, originating at the thoracic arch and extending to near the terminus of the base of the second dorsal. Anterior margin of first dorsal situated in advance of the thoracic arch. Deep chesnut brown above, maculated with yellowish; beneath yellowish."

Specimens collected at San Luis Obispo, Cal., by Lt. W. P. Trowbridge, U. S. A.

ARTEDIUS NOTOSPILOTUS

is characterised by the "surface of the head being subtuberculous and scaly. Preopercle armed with a flat tricuspid spine. Anterior margin of first dorsal situated in advance of the beginning of the dorsal band of scales, which is broad and extends from the thoracic arch to near the terminus of the base of the second dorsal. Olivaceous, with a series of saddle-like black patches. Abdomen dull yellow or white."

Collected by E. Samuels in Tomales Bay, Cal.

Sebastes ruber, Ayres, is my SEBASTES ROSACEUS.

Sebastes nebulosus, Ayres, is my SEBASTES FASCIATUS.

Sebastes variabilis, Ayres (not Cuvier) is my SEBASTES AURICULATUS.

SEBASTES MELANOPS,

is a species hitherto undescribed, and which we thus characterise: "Upper surface of head generally spineless. Posterior extremity of maxillary reaching a vertical line drawn interiorly to the posterior rim of the orbit. Origin of dorsal fin opposite or else slightly in advance of the base of the pectorals. Upper regions blackish brown; sides brownish, spotted with black; beneath greyish brown."

Specimens were collected at Cape Flattery, W. T., and at Astoria, O. T., by Lt. W. P. Trowbridge, U. S. A.

A fine addition to the group of Heterolepids instituted in 1854 with two genera, *Chirus* and *Ophiodon*, is the new genus

OPLOPOMA,

characterised by an "elongated body, membranous flaps above the orbits, and spines on the preopercle. The snout is conical; the mouth large, and the lower jaw the longest. Canine teeth upon the premaxillaries, dentaries, front of vomer and the palatines. Gill openings continuous; branchiostegals six on either side. Dorsal fins contiguous. Caudal posteriorly subcrescentic or else concave. Insertion of ventrals a little posterior to the pectorals. Body covered by small cycloid scales."

OPLOPOMA PANTHERINA,

the only species hitherto known, has the "upper surface and sides of the head granular. The preopercular spines are few, small and blunt. Posterior extremity of maxillary extending beyond the orbit. Origin of anterior dorsal situated in advance of the convexity of the preopercle. Scales extending over the base of both the caudal and pectoral fins. Blackish brown above, reddish brown beneath. Dorsal and lateral regions spotted with black."

Specimens of this species were collected by Lt. W. P. Trowbridge, at Cape Flattery, W. T.

GASTEROSTEUS SERRATUS, Ayres, I have investigated carefully, and found specifically distinct from its congeners.

I describe another species akin to it and *G. plebeius*.

GASTEROSTEUS INTERMEDIUS

having the "body plated all over; the peduncle of the tail keeled. Dorsal spines three, moderate in development and inconspicuously serrated upon their edges; anterior one inserted immediately behind the base of the pectorals. Insertion of ventrals under the second dorsal spine; their own spine being serrated upon both edges, more conspicuously above than below, and their extremities not extending as far as the tips of the *ossa innominata*. Posterior margin of caudal concave."

Inhabits Cape Flattery, W. T., where it was collected by Lt. W. P. Trowbridge, U. S. A.

Finally, under the name of

GASTEROSTEUS PUGETTI,

I introduce a new species in which the "body is only plated in part. Dorsal spines three, slender, not serrated upon their edges; anterior inserted immediately behind the base of pectorals. Insertion of ventrals in advance of the second dorsal spine; their own spine being slender, crenated upon its edges and extending beyond the tips of the *ossa innominata*. Posterior margin of caudal slightly emarginated."

Fort Steilacoom, Puget Sound, W. T.; collected by Dr. Geo. Suckley, U. S. A.

LEIOSTOMUS LINEATUS, Ayres, has come within my observation. The species is characteristic. Specimens of it were brought home by Dr. J. S. Newberry.

LEPTOGUNELLUS GRACILIS, Ayres, I have likewise examined on specimens collected by Dr. Newberry and labelled by Dr. Ayres.

GOBIUS NEWBERRYI

is a small and very graceful species of Goby, hitherto undescribed. The average size of many specimens observed is about two inches or less, the head forming the fourth of the total length. The first dorsal is contiguous to the second at its base, and is considerably lower than the latter. The mouth is deeply cleft, the posterior extremity of the maxillary extending to a vertical line passing posteriorly to the orbit. The origin of the anal is situated a little behind the anterior margin of the second dorsal: both fins terminate evenly, as far as concerns the tips of the posterior rays. The caudal forms the fifth of the total length. The ground color is olivaceous, but the upper regions appear blackish with isolated spots of the ground color; the inferior regions are unicolor.

Atherina storeri, Ayres, is my ATHERINOPSIS CALIFORNIENSIS.

RHACOCHEILUS TOXOTES, Agass., was identified on a specimen collected by E. Samuels in Tomales Bay.

HYSTEROCARPUS TRASKII, Gibbons, could be recognized on a specimen collected at Fort Reading by Drs. J. F. Hammond and John S. Newberry. Another specimen from the same locality had no irregular transverse bands of black, but was almost *unicolor*.

Another species of viviparous fish,

EMBIOTOCA ARGYROSOMA,

is easily distinguished from its congener by the brilliant argentine tint of its entire body, though made a little darker along the dorsal region by a greyish or pinkish hue. The general form is elongated; the head rather small, subconical, rounded anteriorly, and contained four times and a half in the total length. The caudal is deeply forked. The posterior extremity of the anal extends a little more posteriorly than the dorsal. The tips of the pectorals reach a vertical line passing beyond the origin of the anal. Specimens were collected at San Francisco, Cal., by Lt. W. P. Trowbridge, U. S. A.

OSMERUS ELONGATUS, Ayres, has been collected at San Francisco, Cal., by Dr. John S. Newberry. The specimens were identified by Dr. Ayres.

A most important (I was almost going to say unexpected) discovery of a white fish was made by the party on the R. R. Survey of California and Oregon, commanded by Lt. R. S. Williamson. And since it is different from its hitherto known congener, we will call it

COREGONUS WILLIAMSONI,

as commemorative of that Survey. Its head is rather small, being contained about five times in the total length, which measures eleven inches. The mouth is very small and the posterior extremity of the maxillary does not extend as far back as the anterior rim of the orbit. The scales are large; eighteen rows of them may be counted between the anterior margin of the dorsal and the insertion of the ventrals: nine above the lateral line, and eight below it. The lateral line, itself, is perfectly straight. The caudal fin forked as usual. The pectorals are rather small. I have alluded to the color in saying it was a white fish; add to it a bluish grey hue along the back. It was collected by Dr. Newberry in the Des Chutes river, a tributary of the Columbia.

In adding a second species to the genus Platichthys, the diagnose of this genus must be modified so as to read: "eyes on either the right or left side," for

PLATICHTHYS UMBROSUS,

which is the new species referred to, has its eyes on the right, whilst in the species formerly described, they are on the left. It can also readily be distinguished from its congener in having the body completely covered with scales, on the surface of some of which prickles or asperities are observed. The specimen before us measures seven inches and a half, is of a uniform blackish brown hue on the right side and light brown on the left. It was collected by Lt. W. P. Trowbridge, U. S. A., at Cape Flattery, W. T.

I have likewise a second species to add to my genus Pleuronichthys, taking this opportunity of correcting a *lapsus linguæ* which occurred in the diagnosis of its generic characters: "teeth very inconspicuous, occupying the colorless side of the jaws," instead of both sides of the jaw. That this was a mere accident will appear obvious by reading the characters given to Parophrys, in which an allusion is made to the true state of things in Pleuronichthys.

PLEURONICHTHYS GUTTULATUS,

appears to be a smaller species than its congener; it is also deeper, less elongated, hence more of a subcylindrical general form. The eyes are situated on the right side. The origin of the dorsal fin is not quite even with the anterior margin of the orbit, and in that respect the generic diagnosis will undergo a slight modification. The largest specimens observed measure a little over three inches. The ground color appears greyish black, over which are scattered light spots appearing like as many drops irregularly dispersed. Specimens were collected in Tomales Bay by E. Samuels.

A specimen of *Ophidium*, in a too precarious state of preservation to be determined specifically, was found by Lt. W. P. Trowbridge, at S. Farallones, near San Francisco. Another was collected by Dr. Suckley at Shoalwater Bay, W. T., apparently of the same species.

We have also to mention a Sandlaunee, under the name of

AMMODYTES PERSONATUS,

the general aspect of which is shorter than its congeners, although the form and outline of the body are not materially different. We perceive no teeth on the palat. The posterior extremity of the maxillary extends to a vertical line which intersects the anterior rim of the orbit. The origin of the dorsal fin is situated anteriorly to the tips of the pectorals. The base of the caudal fin is black. Specimens were collected at Cape Flattery, W. T., by Lt. W. P. Trowbridge, U. S. A.

SYNGNATHUS CALIFORNIENSIS, Storer,

was received from Monterey, Cal., through the care of A. S. Taylor. The specimen is somewhat imperfect; it is the largest of those which we have examined from the Pacific coast.

ACCIPENSER ACUTIROSTRIS, Ayres,

was brought home by Dr. Newberry, the specimen having been labelled by Dr. Ayres in San Francisco, where the specimen was procured.

ACIPENSER MEDIROSTRIS, Ayres, was received in the same manner as the preceding.

ACIPENSER TRANSMONTANUS, Rich., from the Columbia river, has been collected by Dr. Suckley.

We conclude by referring to a ray of a remarkable genus,

RHINOPTERA VESPERTILIO,

which was caught in Tomales Bay, by E. Samuels. The specimen before us measures nineteen inches and a half from the extremity of the mouth to the tip of the tail, six inches and three quarters being the length of the body and head together. The width from the tip of one pectoral fin to the other is twelve inches. There is a small dorsal fin situated upon the anterior portion of the tail, followed by a flattened spear shaped spine, serrated upon its edge. The tail is very attenuated, flagelliform, tapering into a filiform extremity. The cephalic region is as long as the rest of the body. Its anterior outline is rounded. The eyes are very prominent and somewhat raised above the surface of the head. The respiratory apertures, five in number are transversally elongated and arranged upon an open curve. The lips are fringed. The color is of an uniform bluish slate above; dull whitish beneath.

598.9
cas/Not

[From the Proceedings of the Academy of Natural Sciences, February, 1855.]

Notes on North American Falconidæ, with descriptions of new Species.

By John Cassin.

Since the time at which my Synopsis of the Falconidæ, inhabiting America north of Mexico, was published in the Proceedings of this Academy, (vi. p. 450, December, 1853,) and since, too, the publication of a more extended Synopsis in my Birds of California and Texas, several collections of high interest, containing numerous specimens of birds of this family have been made for account of the Government, principally by parties that have been engaged in surveying routes for a railroad to the Pacific Ocean. Various collections, containing birds of this family have, also, since the periods alluded to, been received by this Academy, in one of which from Greenland, there are specimens of *Hierofalco* of apparently two species, being the only mature American birds of this genus that I have ever seen.

In the present paper, I propose to notice additional localities of previously known species, with such other information as may have been derived from the collections alluded to, forming, in some measure, a continuation of my Synopses above cited. For an opportunity to examine the collections belonging to the Government, I am indebted to the officers of the Smithsonian Institution, in whose custody they are, and more particular descriptions and all information acquired will be published in the Reports of the officers who commanded the various expeditions.

1. Falco nigriceps, Cassin, B. of Cal. and Texas, 1. p. 87, (Dec. 1853.)

The most mature specimen that has ever come under my notice, is in the collection made by J. G. Cooper, M. D., one of the naturalists attached to the Hon. I. I. Stevens' Surveying party. It is labelled as having been obtained at Shoalwater Bay, Washington Territory, March 23d, 1854. The entire upper parts of the body are light bluish cinereous, with which color the head above is more decidedly tinged, than in the specimens originally described by me. The throat and neck in front are white, very faintly tinged with yellowish; other under parts white tinged with ashy and with transverse narrow bars of brownish black, (every feather having about six bars.) Frontal band pure white; under wing coverts pure white with brownish black transverse bars.

In this specimen, there is no trace of the pale yellowish red and circular black spots of the under parts which have appeared in all other specimens that I have seen.

2. Falco polyagrus, Cassin, B. of Cal., and Texas, 1 p. 88, (Dec. 1853.) pl. 16.

Adult specimens of this bird are in the collection made by Dr. Kennerly, who was attached to the surveying party under command of Lieut. A. W. Whipple, U. S. A., in New Mexico; also in those made by Dr. Cooper, of Gov. Stevens' party in Washington Territory, by Lieut. W. P. Trowbridge, U. S. A., in California, and by T. C. Henry, M. D., U. S. A., in New Mexico.

The original descriptions are from female specimens. Those above alluded to are all adults, and do not differ from my description and figure of the adult female in any material point, except that a male in excellent plumage and condition

in Lieut. Whipple's collection is smaller. Its dimensions are as follows:—Total length 16 inches, wing 12¼, tail 7 inches. The young male of this species is in Dr. Henry's collection, and differs from the adult only in being somewhat darker in color, though not so dark as the young female described by me as above.

3. HYPOTRIORCHIS FEMORALIS, (Temm.)

A fine specimen and the first ever noticed within the limits of the United States, is in the collection made by Dr. A. L. Heermann, who was attached to the surveying parties in charge of Lieuts. Williamson and Parke, U. S. A. It is an adult in fine plumage, and precisely identical with the South American bird. It was obtained in New Mexico.*

4. TINNUNCULUS SPARVERIUS, (Linn.)

Numerous specimens from various localities demonstrate that this species inhabits the whole of western (as well as eastern) North America. Specimens from Tamaulipas, Mexico, are in Lieut. Couch's collection; from San Francisco, California, in Lieut. Trowbridge's; from Utah Territory, in Lieut. Beckwith's; and from Milk River, a tributary of the Upper Missouri, in the collection of Dr. George Suckley, attached to the party in charge of the Hon. I. I. Stevens.

5. HIEROFALCO CANDICANS, (Gmelin.)

Falco candicans, Gm. Syst. Nat. i. p. 275, (1788.)
Falco groenlandicus, Daudin, Tr. d'Orn, ii. p. 107, (1800.)
Falco fuscus, Fabricius, Fauna Groenlandica, p. 56, (1780.)?
"Falco arcticus, Holboll." Label on specimens received from Europe.

Adult. ♂ White, under parts with a few longitudinal narrow stripes of brown. Upper parts white, head and neck behind with longitudinal narrow stripes of brown. Plumage of the back, wing coverts and shorter quills with *irregular confluent transverse bands, and large subterminal hastate or bluntly sagittate spots of ashy brown*. Primary quills white with their tips brownish black, and with irregular and imperfect transverse bars of black, confluent on the shafts of the feathers. Tail white, with transverse bars of brownish black in some of the outer feathers, only observable on their outer webs.

Dimensions.—Total length (of skin,) about 24 inches, wing 16, tail 10 inches.

Young. Entire upper plumage with the brown predominating, and of a lighter shade than in the adult, and tinged with ashy; every feather edged with white, and more or less barred and spotted with white, and pale reddish. The brown color showing a tendency to form the bands and sagittate spots of the adult. Under parts white, tinged with ashy, with longitudinal stripes of brown, widest on the abdomen. Quills ashy brown, with transverse bands of white tinged with pale fulvous, tail ashy brown, palest on the middle feathers, every feather edged externally with white, and with imperfect transverse bands (or pairs of large spots,) of white.

This fine species is nearly related to that next described, but can be distinguished by the different style of the brown marking of the upper parts. In the present bird, the large subterminal sagittate or hastate spots are especially characteristic, and this character prevails also in the young bird.

The nomenclature of this and the succeeding species is difficult to determine on account of their similarity.

6. HIEROFALCO ISLANDICUS, (Gmelin.)

Falco islandicus, Gm. Syst. Nat. i. p. 275, (1788.)
Falco islandus, Fabricius Faun. Groenl., p. 58, (1780)?

---

* In Lieut. Couch's collection there are specimens of the following species from Mexico.

1. Hypotriorchis columbarius, (Linn.) from the State of Tamaulipas.

2. Hypotriorchis rufigularis, (Daudin.) from the State of New Leon. This species has not yet been detected within the limits of the United States; but as the State of New Leon is only separated from Texas by the Rio Grande, it will very probably be found in the State last mentioned.

Adult ♂. White, beneath with a few narrow longitudinal lines of dark brown, most observable on the sides and flanks. Upper parts white, on the head and neck behind with narrow longitudinal lines and stripes of dark brown. Plumage of the back, upper wing coverts, and tertiaries white, *with regular transverse bands of brown, becoming somewhat crescent shaped on the scapulars and rump*, and slightly acuminate on the shafts of the feathers. Primaries white, brownish-black at their ends, and with imperfect, confluent, transverse bands of brown. Tail white, with about twelve transverse bands of brown.

Young. Entire upper plumage brown, with transverse bands of dull white, generally interrupted and imperfect in the middle of the feather. Under parts dull white, with numerous circular and irregular-shaped spots of dark brown, largest on the sides, and disposed to form transverse bands on the tibiæ and flanks. Quills dark brown, with transverse bands of white tinged with fulvous on their inner webs; tail dark brown with transverse bands of ashy white.

Dimensions.—Total length (of skin) about 24 inches, wing 16¼, tail 10 inches.

Specimens in the collection from Greenland are strictly identical with others in the collection of the Academy which were presented by our distinguished members, Messrs. Thomas B., and Edward Wilson, and carefully ascertained to be undoubted Iceland specimens by the latter gentleman.

In the present species the entire upper parts are transversely and nearly regularly barred with brown, and the under parts less spotted than in the preceding. The young bird also presents the same character on the upper parts in some degree, while the under parts are spotted and transversely striped only, and not with the numerous longitudinal stripes of the young of the preceding.

These two birds appear to be different species so far as I can judge from the specimens before me, and are so regarded by nearly all modern authors. They are, however, nearly related, and I am not without a suspicion of their identity.

7. Astur atricapillus, (Wilson).

A specimen in Dr. Suckley's collection from the Columbia river, in Oregon. This is the only western specimen that has ever come under my notice.

8. Accipiter Cooperii, (Bonaparte).

Specimens from near San Francisco, California, in Lieut. Trowbridge's collection, and from Yakima river, Washington Territory, in that made by Dr. Cooper.

9. Accipiter mexicanus, Swainson.

Excellent specimens of adults and young from New Mexico are in the collection of T. C. Henry, M.D., U. S. Army.

10. Accipiter fuscus, (Gmelin).

From Shoalwater Bay, Washington Territory, in Dr. Cooper's collection; and from near San Francisco, California, in a Collection made by Mr. R. D. Cutts.

11. Buteo borealis, (Gmelin).

In the comparison of numerous specimens of adults and young from various localities in Western North America, with others obtained in the vicinity of Philadelphia, I have failed to detect any differences not consistent with specific identity. There is in some specimens a greater extent of the brown color on the breast, and a deeper shade of rufous on the abdomen and tibiæ, than is usual in eastern specimens, but I have found no character in the western bird that I have not seen at some time in the other. In my Synopsis I have erroneously regarded this bird as *Buteo Swainsonii*, which I have reason to suppose, as will appear in my notice of that species in the present paper, has also been done by other writers.

12. Buteo Bairdii, Hoy, Proc. Acad., Philada., vi. p. 452.

The only specimen yet obtained in Western America is in the collection made by Mr. Kreutzfeldt, who was attached to the party in charge of Lieut. E. G. Beckwith, U. S. Army. It is very similar to the specimen regarded as the more adult of the two described as above cited, but has the brown spots on the under parts larger, and the tibiæ transversely barred with dark brown, and tinged

with rufous. It is labelled as having been obtained on the Rio Grande, in the territory of Utah.

13. BUTEO SWAINSONII, Bonaparte.

In the collection made by Mr. Kreutzfeldt, of Lieut. Beckwith's party, there are three specimens undoubtedly of this species, and the first that I have ever seen.

This species is a typical *Buteo*, and though I cannot regard it as identical with the European *Buteo vulgaris*, it is more nearly related to it than is any other American species with which I am acquainted. Like that species, too, it presents a marked variation in the colors of different specimens, the present three being all unlike each other in a considerable degree. One specimen is almost exactly of the form, dimensions and colors as originally described and figured by Mr. Swainson, in Fauna Boreali Americana, Birds p. 47, pl. 27, and stated by him to have been made (both description and figure) from a male bird. On the specimen described by Mr. Swainson, as a female, (in the work just mentioned, p. 49,) I shall venture some observations below.

The first and apparently most mature specimen is as follows:

Bill wide at base, compressed towards the tip, edge of the upper mandible lobed, cere large. Wing long, third quill longest, tail moderate, rather wide, truncate, tarsus feathered in front for nearly half its length, naked behind, bare portion presenting in front about twelve transverse scales, toes rather short, claws strong. Entire upper parts dark brown, nearly black in the middle of many feathers, and paler on their edges. Quills brownish black, with wide, transverse bands of cinereous on their inner webs, becoming paler and nearly pure white towards their bases. Tail brown, tinged with ashy, and having transverse bands of a darker shade of brown, the subterminal of which is widest, tip edged with white. Throat white, with longitudinal lines of dark brown, *neck before and breast ashy brown*, some of the feathers edged with reddish. Other under parts white, nearly pure on the under tail coverts, and strongly tinged, and with transverse, irregular bars of rufous on the tibiæ, abdomen with numerous irregular and imperfect narrow transverse bars of brown tinged with reddish. Under wing coverts white, with a few spots and transverse stripes of brown. Bill dark slate color, tarsi and toes yellow.

Dimensions.—Total length (of skin,) 21¼ inches, wing 16, tail 8½, tarsus 2¼ inches.

The second specimen has the upper parts as just described, but darker. Throat white, faintly tinged with yellowish, (without stripes of brown,) *breast dark brown, (nearly black)*, and the other under parts pale rufous, darker on the tibiæ, and with transverse stripes of brown on all the under parts less numerous than on the abdomen of the preceding specimen, and more irregular. Total length (of skin) 20½ inches, wing 15½, tail 8¼.

The third specimen has the upper parts about the same shade of brown as the first described above, but with the tail darker, and the transverse bands more indistinct. Throat white, with a few longitudinal lines of black, *neck before and breast light rufous*, some of the feathers ashy brown in the middle, other under parts white nearly pure and unspotted on the lower part of the abdomen and on the under tail coverts, tinged with very pale reddish on the tibiæ, upper portion of abdomen and flanks nearly pure white with a few spots and transverse bars of fulvous and dark brown. Total length (of skin) 20 inches, wing 15¼, tail 8 inches.

In all these specimens the color of the neck before and of the breast, may be said to form a wide uninterrupted transverse belt or band, and is a very conspicuous and apparently constant character. The sexes of these specimens are not stated in the labels attached to them.

The tail in the specimens above varies merely in shade of the same brown color. In the first and apparently the most mature specimen, it is strongly tinged with cinereous. There is no tendency to become red in the tail of either specimen.

Although I have no doubt whatever that this is the species indicated by the description of Mr. Swainson as above cited, my opinion is that it is the male bird only to which this conclusion applies.

The female described by Mr. Swainson does not appear to me to be of the same species, but apparently is that of the *Buteo borealis*, in plumage not mature. A careful examination of the descriptions of the male and female here alluded to, which are given by Mr. Swainson with his usual great accuracy, will show some material points of difference. Of the male it is stated that "the *third* quill feather is the longest, the *fourth* is nearly a quarter of an inch, and the *second* an inch and a quarter shorter." Of the female "the *third* and *fourth* quill feathers are of equal length." Of the male "cere and legs yellowish,"—of the female "the cere and legs have a bluish livid color." The last character may, however, only indicate a young bird, and that the specimen was a young bird, is further rendered probable by the statement that "the feathers are more downy" than those of the male. The total length of the male is given as 22 inches, that of the female 26 inches. All the measurements of the female as given, and the description, apply to the immature *Buteo borealis*, especially to western specimens.

The bird figured by Mr. Audubon as *Falco buteo* (B. of Am. pl. 372) is the young bird of *Buteo borealis* and not the present species. European naturalists generally have regarded this bird as either identical with that species, or as nearly related to it, both of which conclusions are erroneous.

14. Buteo calurus, nobis.

Form.—Similar in general form to *Buteo augur*, *tachardus* and *vulgaris*. Bill strong, edges of the upper mandible with distinct rounded lobes, wings long, fifth quills slightly longest, tail moderate (or rather short). Tarsi feathered in front for nearly half their length, naked behind, naked portion in front presenting about ten transverse scales, claws large, strong, fully curved.

Dimensions.—(Of skin) sex unknown. Total length about 21 inches, wing 16½, tail 9 inches.

Colors.—Tail bright rufous above, white at the base, every feather having about eight irregular and imperfect transverse narrow bands and one wide subterminal band of brownish black, beneath silky reddish white. Entire plumage of the head, neck and body above and below dark brown, nearly black on the back and abdomen and palest on the breast. Plumage of the upper parts with partially concealed transverse bands of white, and of the under parts with circular spots and transverse bands of the same (also partially concealed). Quills dark brown, with a large portion of their inner webs white, banded and mottled with pale ashy brown. Tibial feathers and under tail coverts transversely barred with dark brown and pale rufous.

Hab.—New Mexico, discovered by T. Charlton Henry, M. D,, United States Army. This new and very remarkable bird presents a combination of characters quite unusual in an American species, and it bears a greater resemblance to a Northern African species, *Buteo augur*, Rüppell, than to any other with which I am acquainted. In some degree it also resembles my *Buteo insignatus* (B. of Cal. and Texas i. p. 102, pl. 31), but is much larger, and presents various other strong points of difference. The present bird would present to a casual observer the appearance of the Black Hawk (*Archibuteo sancti-johannis*) with the tail attached of the common red-tailed Buzzard (*Buteo borealis*), a combination hitherto unknown amongst American Falconidæ, but which exists in the African *Buteo augur*.

The bird now described is in an extensive collection containing many interesting and little known species, made by Dr. T. C. Henry of the United States Army, whose exertions have continued unremitted for several years. It was obtained in the vicinity of Fort Webster, New Mexico.

15. Buteo elegans, nobis.

Form.—Generally similar to *Buteo lineatus*. Bill rather slender, edges of

the upper mandible with a rounded not well defined lobe, wing moderate, fourth quill longest, first quill short, tail moderate, wide, rounded. Tarsus feathered in front slightly below the joint with the tibia, naked behind, naked portion in front presenting about twelve transverse scales.

Dimensions.—Total length, adult male? (of skin) about 19 inches, wing 13, tail 8 inches.

Colors.—Adult, generally resembling those of *Buteo lineatus*. Throat dark brown with white longitudinal lines. Entire under parts bright rufous, darker and unspotted on the breast, lighter on the abdomen, tibiæ and under tail coverts and with transverse bands of pale reddish white; the latter (white) purer at the bases of the feathers. Abdomen, tibiæ and under tail coverts uniformly colored.

Entire upper parts dark brown, feathers of the head and back edged with dark rufous, upper coverts of the tail narrowly tipped with white. Shoulders dark rufous, every feather with a narrow central stripe of dark brown, superior coverts of the wings dark brown, edged on their inner webs with rufous and with transverse stripes partially concealed, and circular spots of white, and tipped with the same. Quills brownish black, primaries and secondaries with numerous irregular transverse bands of white, running obliquely on their inner webs, all the quills widely tipped with white. Tail brownish black, white at base, and having four transverse bands of white and tipped with the same. Under wing coverts rufous, barred with reddish white, uniform with the abdomen and under tail coverts.

Dimensions.—Total length (of skin) male? 19 inches, wing 13, tail 8¼ inches.

Young. Upper parts brown, plumage of the head edged with reddish white and on the back with rufous, quills with their inner webs barred with white and dark brown, the bands of the former (white) much the widest and narrowly edged with rufous, all the quills narrowly tipped with white. Tail dark brown, with four transverse bands of ashy white, purer on the inner webs and narrowly tipped with white. Throat dark brown, with longitudinal narrow stripes of white, other under parts dull yellowish white, every feather with wide transverse and confluent bands of dark brown, and at its end a large arrow head of the same color. These bands and sagittate spots giving the predominating color (brown) to the breast and sides, but less numerous on the abdomen and under tail coverts. Tibial feathers, inferior coverts of the wing and some feathers of the shoulders pale rufous. Total length (of skin) 18 inches, wing 12½, tail 8¼ inches.

Hab.—California, (Dr. Heermann;) New Mexico, (Dr. Kennerly.)

This bird, the adult and young of which are in a collection made by Dr. Heermann, in California, and another young specimen in Lieut. Whipple's collection, bears a considerable resemblance to *Buteo lineatus*. The entire under parts are, however, of a different red color, and continued to the abdomen and under tail coverts. In the present species, this color is nearly a clear brick red; while in *B. lineatus*, it is more of an orange color, and in the latter, the lower part of the abdomen, and under coverts are nearly pure white in adult specimens. The under parts in the young birds of the present species are entirely and strikingly different from those of its relative mentioned.

16. BUTEO OXYPTERUS, nobis.

Form.—About the size of *Buteo pennsylvanicus*, (Wilson). Bill rather long and compressed, edge of the upper mandible slightly waved in its outline, but scarcely lobed; wing long, third quill distinctly longest, tail rather short, legs rather long, tarsus feathered in front for about one third of its length, naked behind, and with its naked portion in front, presenting about fourteen narrow transverse scales, claws large, strong, fully curved.

Dimensions.—Total length (of skin,) sex unknown, about 16 inches, wing 13½, tail 7 inches.

Colors.—(Young bird, sex unknown.) Entire plumage above dark brown, nearly black on the back. Feathers of the head white at base and edged laterally with the same; many feathers of the upper parts of the body also white at

their bases, and with partially concealed transverse bands of white, quills very dark brown (nearly black,) with the inner webs dark cinereous barred with brown, tail above ashy brown, all the feathers white at base, and having about ten transverse bands of dark brown, outer feathers (of the tail) ashy white on their inner webs, tail beneath silky ashy white, with a bronzed yellowish olive lustre.

Behind and under the eye a stripe of rufous brown. Under parts pale yellowish white, throat with lines and narrow stripes of brownish black, and on other under parts every feather with a large lanceolate, circular or cordate spot of dark brown, some feathers on the flanks and sides having also some irregular transverse bands of the same color. Nearly all the feathers on the under parts with lines of dark brown on their shafts.

Quills with their inner webs on the under surface of the wing grayish or dark ashy, and near the shafts with a bronzed olive lustre; shafts white (on the under surface.) Inferior wing coverts white with arrow heads of dark brown. Tibial feathers yellowish white, tinged with rufous, and having irregular transverse bars of dark brown.

Adult, black?

Hab.—New Mexico. Discovered by T. Charlton Henry; M.D., U. S. Army.

The specimen now described is the young of a species the adult of which is as yet unknown. It is about the size of *B. pennsylvanicus*, with the wings and legs much longer and the bill also somewhat longer. The colors, too, are different, and in the present bird the dark cinereous of the inner webs of the quills and the bronzed or silky olive lustre on their inferior surfaces are especially remarkable. The exposed edges and ends of some of the secondaries in the present specimen have a distinct purple lustre. I suspect that the adult of this bird is black.

This bird is in the valuable collection made by T. C. Henry, M.D., U. S. Army, and is from the vicinity of Fort Webster, New Mexico.

17. ARCHIBUTEO LAGOPUS, (Gmelin.)

A specimen is in Dr. Cooper's collection from Shoalwater Bay, Washington Territory, and another is in Dr. Kennerly's collection from the River Zuni in New Mexico.

18. ARCHIBUTEO FERRUGINEUS, (Licht.)

Specimens of adults and young birds in Dr. Heermann's collection.*

19. ELANUS LEUCURUS, (Vieill.)

Specimens from near San Francisco, California, in a collection made by Mr. R. D. Cutts.

20. CIRCUS HUDSONIUS, (Linn.)

Specimens from Minnesota Territory are in Dr. Suckley's collection, from Utah Territory in Mr. Kreutzfeldt's, from New Mexico, in Capt. Pope's, Lieut. Whipple's and Dr. Henry's, and from Tamaulipas, Mexico, in Lieut. Couch's collection.

21. AQUILA CHRYSAETOS, (Linn.)

In Dr. Henry's collection from New Mexico.

22. HALIAETUS ALBICILLA, (Linn.)

In the collection from Greenland there is a fine specimen of this bird. We notice no material difference between it and others from various European localities.

23. HALIAETUS LEUCOCEPHALUS, (Linn.)

Dr. Cooper's collection contains a specimen in immature plumage, which was obtained at Shoalwater Bay, Washington Territory.

---

*As probably belonging to the *Buteonidæ*, we may mention here that the following species is in Lieut. Couch's collection, and having been obtained by him in the northern part of the State of New Leon, Mexico, may be expected to occur in Texas:

1. ASTURINA CINEREA, Vieill. Gal. des Ois. i. pl. 20.

24. POLYBORUS THARUS, (Molina.)

Specimens are in a collection made by Mr. Arthur Schott, while attached to the Mexican Boundary Commission in charge of Major W. H. Emory, U. S. Army. They were obtained in Texas.

25. MORPHNUS UNICINCTUS, (Temm.)

Specimens are in the collections made in Texas by Mr. Schott, Dr. Kennerly and Lieut. Couch.

1776. 1876.

U. S. Centennial Exhibition

CATALOGUE

TO ILLUSTRATE THE

Animal Resources of the Dominion of Canada.

PREPARED BY

DR. A. M. ROSS, F.L.S., F.Z.S.

TORONTO, CANADA.

FUR-BEARING, USEFUL, AND INJURIOUS ANIMALS.

ORDER FERÆ.

FELIDÆ.

1. LYNX RUFUS
   Wild Cat,
   Eastern Provinces of the Dominion
2. LYNX CANADENSIS,
   Canada Lynx,
   Eastern Provinces of the Dominion
3. FELIS CONCOLOR,
   Panther, or Painter,
   Dominion generally.

CANIDÆ.

4. CANIS LUPUS,
   White, Black, Red and Gray Wolf,
   Canada generally.
   a. Gray Wolf (var. *griseo-albus*).
   b. Dusky Wolf (var. *nubilus*).
   c. Black Wolf (var. *niger*).
5. CANIS LATRANS,
   Coyote; Prairie Wolf,
   Manitoba and North-west Ter.
6. VULPES ALOPEX, *subspecies* Fulvus,
   Red Fox,
   Canada generally.
   a. Common Fox (var. *fulvus*).
   b. Cross Fox (*decussatus*).
   c. Silver Fox (var. *argentatus*).
7. VULPES ALOPEX, *subspecies*
   Prairie Fox.
   Manitoba and British Columbia.
8. VULPES VELOX,
   Kit Fox; Swift Fox,
   Manitoba and British Columbia.
9. VULPES LAGOPUS,
   Arctic Fox,
   Northern Canada.
10. UROCYON VIRGINIANUS,
    Gray Fox,
    Dominion of Canada generally.

MUSTELIDÆ.

MUSTELINÆ.

11. MUSTELA PENNANTI,
    Fisher; Black Cat,
    Eastern Provinces of the Dominion

12. MUSTELA AMERICANA,
Pine Marten ; American Sable,
Eastern Provinces of the Dominion
13. PUTORIUS ERMINEA,
White Weasel ; Ermine,
Eastern Provinces of the Dominion
14. PUTORIUS LONGICAUDA,
Long-tailed Weazel,
Manitoba.
15. PUTORIUS VISON,
Brown Mink,
Ontario, Quebec, New Brunswick and Nova Scotia.
16. PUTORIUS NIGRIPES,
Black-footed Ferret,
Manitoba.
17. GULO LUSCUS,
Wolverine,
Canada generally.

MELINÆ.

18. TAXIDEA AMERICANA,
Missouri Badger,
Manitoba and Pacific slope.

MEPHITINÆ.

19. MEPHITIS MEPHITICA,
Common Skunk,
Dominion generally.
20. SPILOGALE ZORILLA,
Little Striped Skunk,
Dominion generally.

LUTRINÆ.

21. LUTRA CANADENSIS,
American Otter,
Atlantic and Pacific Coast.

ENHYDRINÆ.

22. ENHYDRA MARINA,
Sea Otter,
Pacific Coast of the Dominion.

URSIDÆ.

23. URSUS HORRIBILIS,
Grizzly Bear,
British Columbia & Pacific slope.
24. URSUS AMERICANUS,
Black Bear,
Dominion generally.
25. THALARCTOS MARITIMUS,
White or Polar Bear,
Arctic Canada.

PROCYONIDÆ.

26. PROCYON LOTOR,
Common Raccoon,
Dominion generally.

PINNIPEDIA.

OTARIIDÆ.

27. CALLIRHINUS URSINUS,
The Fur Seal,
Pacific Coast.
28. EUMETOPIAS STELLERI,
The Sea Lion,
Coast of British Columbia.
29. ZALOPHUS GILLIESPII,
The Sea Dog,
Coast of British Columbia.

PHOCIDÆ.

PHOCINÆ.

30. PHOCA VITULINA,
The Common Seal ; Harbor Seal,
Atlantic Coast.
31. PHOCA RICHARDSII,
The Leopard Seal,
Pacific Coast.
32. PAGOMYS FŒTIDUS,
The Ringed Seal,
Arctic Seas.
33. PAGOPHILUS GRŒNLANDICUS
The Harp Seal,
Arctic Seas.
34. ERIGNATHUS BARBATUS,
The Square-flipper Seal,
Arctic Seas.
35. HISTRIOPHOCA EQUESTRIS,
The Banded Seal,
Pacific Coast, Arctic Seas.
36. PUSA GRYPHUS,
The Gray Seal,
Atlantic Coast.

CYSTOPHORINÆ.

37. CYSTOPHORA CHRISTATA,
The Hooded Seal,
Atlantic Coast.
38. MACRORHINUS ANGUSTIROSTRIS,
The Sea Elephant ; Elephant Seal
Pacific Coast.

ROSMARIDÆ.

39. ROSMARUS OBESUS,
The [Atlantic] Walrus,
Atlantic Coast.
40. ROSMARUS COOKII,
The [Pacific] Walrus,
Pacific Coast.

ORDER UNGULATA.

BOVIDÆ.

BOVINÆ.

41. BISON AMERICANUS,
American Buffalo,
Plains of Manitoba, and British Columbia, east of Rocky Moun.

42. OVIBUS MOSCHATUS,
Musk Ox,
Barren grounds of Arctic Canada

ANTILOPINÆ.

43. MAZAMA MONTANA,
Mountain Goat,
Nor. Mountains of B. Columbia.

OVINÆ.

44. OVIS MONTANA,
Bighorn; Mountain Sheep,
Rocky Mountain Regions.

ANTILOCAPRIDÆ.

45. ANTILOCAPRA AMERICANA,
Antelope; Prong-horn Antelope; Cabree.
Plains of the Saskatchewan.

CERVIDÆ.

46. ALCES MALCHIS,
Moose,
North-eastern Canada.

47. TARANDUS CANADENSIS,
Woodland Caribou,
New Brunswick and west to north shore of Lake Superior.

48. TARANDUS RANGIFER, *subspecies* grœnlandicus,
Barren Ground Caribou,
Barren grounds of Arctic Canada

49. CERVUS CANADENSIS,
American Elk,
Northern Canada.

50. CARIACUS VIRGINIANUS,
Virginia Deer,
Eastern Provinces of Canada.

51. CARIACUS MACROTIS,
Mule Deer,
Manitoba and N.-W. Territory.

52. CARIACUS COLUMBIANUS,
Columbia Black-tailed Deer,
Pacific Slope.

ORDER CETE.

DELPHINIDÆ.

DELPHINAPTERINÆ.

53. DELPHINAPTERUS CASTODON
The White Whale,
Arctic and subarctic seas (ascending large rivers).

54. MONODON MONOCEROS,
The Narwhal,
Arctic Seas.

DELPHININÆ.

55. LEUCORHAMPHUS BOREALIS,
The Right-whale Porpoise,
Pacific Coast.

56. DELPHINUS BAIRDII,
Baird's Porpoise,
Coast of British Columbia.

57. DELPHINUS CLYMENE,
Porpoise,
Atlantic Coast.

58. TURSIOPS EREBENNUS,
The [Eastern] Porpoise,
Atlantic Coast.

59. TURSIOPS GILLII,
The [Pacific] Cowfish,
Pacific Coast.

60. LAGENORHYNCHUS OBLIQUIDENS,
The Striped or Common Porpoise,
Pacific Coast.

61. LAGENORHYNCHUS LEUCOPLEURUS,
The [Atlantic] Cow-fish,
Atlantic Coast.

62. LAGENORHYNCHUS THICOLEA,
The [Pacific] Porpoise,
West Coast of the Dominion.

63. ORCA ATRA,
The [Pacific] Killer,
Pacific Coast.

64. ORCA GLADIATOR,
The [Atlantic] Killer,
Atlantic Coast.

65 PHOCÆNA VOMERINA,
The Bay Porpoise,
Pacific Coast.

66. PHOCÆNA AMERICANA,
The Snuffer or Puffing Pig,
Atlantic Coast.

GLOBICEPHLINÆ.

67. GLOBICEPHALUS SCAMMONI,
The [Pacific] Black-fish,
Pacific Coast.

68. GLOBICEPHALUS INTERMEDIUS,
The [Atlantic] Black-fish,
Atlantic Coast.

69. GRAMPUS STEARNSII,
The White-headed or Mottled Grampus,
Pacific Coast.

ZIPHIIDÆ.

ZIPHIINE.

70. MESOPLODON SOWERBIENSIS
Sowerby's Whale,
Atlantic Coast.

ANARNACINÆ.

71. ANARNACUS SEMIJUNCTUS,
The Bottle-head,
Atlantic Coast.

BALÆNOPTERIDÆ.

AGAPHELINÆ.

72. AGAPHELUS GIBBOSUS,
The Scragg Whale,
Atlantic Ocean.

73. RHACHIANECTES GLAUCUS,
The Gray Whale,
Pacific Coast.

MEGAPTERINÆ.

74. MEGAPTERA VERSABILIS,
The [Pacific] Humpback Whale,
Pacific Coast.

75. MEGAPTERA OSPHYIA,
The [Atlantic] Hump-back Whale
Atlantic Coast.

76. ESCHRICHTIUS ROBUSTUS,
The Graso Whale,
Atlantic Coast.

BALÆNOPTERINÆ.

77. SIBBALDIUS TECTIROSTRIS,
The [common] Finback Whale.
Atlantic Ocean.

78. SIBBALDIUS TUBEROSUS,
The [Eastern] Finback Whale,
Atlantic Ocean.

79. SIBBALDIUS BOREALIS,
The [Atlantic] Sulphur-bottom Whale,
Atlantic Ocean.

80. SIBBALDIUS SULFUREUS,
The [Pacific] Sulphur-bottom Whale,
Pacific Ocean.

81. BALÆNOPTERA ROSTRATA,
The Grampus.
Atlantic Ocean.

82 BALÆNOPTERA VELIFERA,
The Finback Whale; Oregon Finner
Pacific Coast.

83. BALÆNOPTERA DAVIDSONII,
The Sharp-headed Finner Whale,
Pacific Coast.

BALÆNIDÆ.

84. BALÆNA MYSTICUS,
The Bowhead Whale,
Arctic Seas.

85. EUBALÆNA CULLAMACH,
The [Pacific] Right Whale,
Pacific Coast.

86. EUBALÆNA CISARCTICA,
The [Atlantic] Right Whale.
Atlantic Coast.

ORDER INSECTIVORA.

TALPIDÆ.

87. SCALOPS AQUATICUS,
Common Mole,
Eastern Canada.

88. SCALOPS ARGENTATUS,
Silvery Mole,
Western Canada.

89. SCAPANUS TOWNSENDII,
Oregon Mole,
Pacific slope.

90. SCAPANUS BREWERI,
Hairy-tailed Mole,
Eastern Canada.

91. CONDYLURA CRISTATA,
Star-nosed Mole,
Eastern and Northern Canada.

ORDER GLIRES.

SCIURIDÆ.

92. SCIURUS CINEREUS,
Fox Squirrel,
Ontario and Manitoba.

93. SCIURUS CAROLINENSIS,
Gray Squirrel,
Cross Squirrel (*decussatus.*)
Eastern Canada.

94. SCIURUS HUDSONIUS,
Red Squirel ; Chickaree,
Canada generally.

95. SCIURUS CANADENSIS,
Black Squirel,
Eastern Provinces of the Dominion

96. TAMIAS STRIATUS,
Chipmunk,
Eastern Canada.

97. TAMIAS QUADRIVITTATUS,
Striped Mountain Squirel,
Pacific slope, in mountains.

98. TAMIAS LATERALIS,
Say's Striped Squirrel,
Manitoba and N.-W. Territory.

99. PTEROMY'S VOLUCELLA,
Flying Squirrel.

100. SPERMOPHILUS FRANKLINI,
Gray Gopher,
Manitoba and N.-W. Territory.

101. SPERMOPHILUS TRIDECEMLINEATUS,
Striped Gopher; Prairie Squirel,
Manitoba.

102. SPERMOPHILUS PARRYI,
Parry's Marmot,
Northern Parts of Canada, from Hudson's Bay to Behring's Strait.

103. SPERMOPHILUS RICHARDSONI
Yellow Gopher
Plains of the Saskatchewan and Southward.

104. SPERMOPHILUS TOWNSENDI,
Townsend's Ground Squirrel,
Plains of British Columbia.

105. CYNOMYS LUDOVICIANUS,
Prairie Dog,
British Columbia, and Manitoba, east of the Rocky Mountains.

106. ARCTOMYS MONAX,
Woodchuck ; Groundhog,
Eastern Canada.

107. ARCTOMYS CALIGATUS,
North-western Marmot,
Manitoba and British Columbia.

HAPLODONTIDÆ.

108. HAPLODONTIA LEPORINA,
Sewellel ; Showt'l,
Pacific slope.

CASTORIDÆ.

109. CASTOR CANADENSIS,
American Beaver,
Canada generally.

GEOMYIDÆ.

110. THOMOMYS TALPOIDES,
Californian Gopher,
Northern and Western Canada.

111. THOMOMYS CLUSIUS,
Small-footed Pouched Gopher,
Rocky Mountains.

MURIDÆ.

112. MUS DECUMANUS,
Brown Rat,
Canada generally. (Introduced).

113. MUS RATTUS,
Black Rat,
Canada generally, but rare. (Introduced.)

114. MUS MUSCULUS,
Common Mouse,
Canada generally. (Introduced.)

115. HESPEROMYS LEUCOPUS,
White-footed Mouse,
Manitoba and North-west Territory.

116. NEOTOMA CINEREA,
Rocky Mountain Rat,
Pacific Slope.

117. FIBER ZIBETHICUS,
Musk Rat,
Canada generally.

HYSTRICIDÆ.

118. ERETHIZON DORSATUS,
White-haired Porcupine,
Eastern and Northern Canada.

119. ERITHIZON EPIXANTHUS, (var. *dorsatus*),
Yellow-haired Porcupine,
British Columbia and Manitoba.

Sub-order DUPLICIDENTATA.

LEPORIDÆ.

120. LEPUS GLACIALUS,
Polar Hare,
Arctic and Sub-Arctic Canada.

121. LEPUS AMERICANUS,
Northern Hare; White Rabbit,
Northern and Eastern Canada.

122. LEPUS WASHINGTONII,
Red Hare,
British Columbia.

123. LEPUS CAMPESTRIS,
Prairie Hare,
Manitoba and N.-W. Territory.

124. LEPUS SYLVATICUS,
Gray Rabbit,
Eastern Canada.

NATIVE AND MIGRATORY BIRDS

OF THE

DOMINION OF CANADA.

ORDER I.—RAPTORES.

BIRDS OF PREY.

1. CATHARTES CALIFORNIANUS
   California Vulture.
2. FALCO ANATUM,
   Duck Hawk.
3. FALCO NIGRICEPS,
   Black Capped Hawk,
4. FALCO POLYAGRUS,
   Prairie Falcon.
5. HYPOTRIORCHIS COLUMBARIUS,
   Pigeon Hawk.
6. TINNUNCULUS SPARVERIUS,
   Sparrow Hawk.
7. ASTUR ATRICAPILLUS,
   Goshawk.
8. ACCIPITER COOPERII,
   Cooper's Hawk.
9. ACCIPITER FUSCUS,
   Sharp-shinned Hawk.
10. BUTEO SWAINSONI,
    Swainson's Hawk.
11. BUTEO BAIRDII,
    Baird's Hawk.
12. BUTEO CALURUS,
    Black Red-tail.
13. BUTEO INSIGNATUS,
    Brown Hawk.
14. BUTEO HARLANII,
    Harlan's Hawk.
15. BUTEO BOREALIS,
    Red-tailed Hawk.
16. BUTEO MONTANUS,
    Western Red-tail.
17. BUTEO LINEATUS,
    Red-shouldered Hawk.
18. BUTEO PENNSYLVANICUS,
    Broad-Winged Hawk.
19. BUTEO OXYPTERUS,
    Sharp-winged Hawk.
20. ARCHIBUTEO LAGOPUS,
    Rough-legged Hawk.
21. ARCHIBUTEO SANCTI-JOHANNIS,
    Black Hawk.
22. ARCHIBUTEO FERRUGINEUS,
    Squirrel Hawk.
23. NAUCLERUS FURCATUS,
    Swallow-tailed Hawk.
24. CIRCUS HUDSONIUS,
    Marsh Hawk.
25. AQUILA CANADENSIS,
    Golden Eagle ; Ring-tailed Eagle.
26. HALIAETUS PELAGICUS,
    Northern Sea Eagle.
27. HALIAETUS WASHINGTONII,
    Washington Eagle.
28. HALIAETUS ALBICILLA,
    Gray Sea Eagle.
29. HALIAETUS LEUCOCEPHALUS
    Bald Eagle.
30. PANDION CAROLINENSIS,
    Fish Hawk.
31. STRIX PRATINCOLA,
    Barn Owl.

32. BUBO VIRGINIANUS,
Great Horned Owl.
33. SCOPS ASIO,
Mottled Owl.
34. SCOPS McCALLII,
Western Mottled Owl.
35. OTUS WILSONIANUS,
Long Eared Owl.
36. BRACHYOTUS CASSINII,
Short-eared Owl.
37. SYRNIUM CINEREUM,
Great Grey Owl.
38. SYRNIUM NEBULOSUM,
Barred Owl.
39. NYCTALE RICHARDSONII,
Sparrow Owl.
40. NYCTALE ALBIFRONS,
Kirtland's Owl.
41. NYCTALE ACADICA,
Saw-whet Owl.
42. ATHENE HYPUGAEA,
Prairie Owl.
43. ATHENE CUNICULARIA,
Burrowing Owl.
44. GLAUCIDIUM GNOMA,
Pigmy Owl.
45. NYCTEA NIVEA,
Snowy Owl.
46. SURNIA ULULA,
Hawk Owl.

ORDER II.—SCANSORES.

CLIMBERS.

47. COCCYGUS AMERICANUS,
Yellow-billed Cuckoo.
48. COCCYGUS ERYTHROPHTHALMUS,
Black-billed Cuckoo.
49. PICUS VILLOSUS,
Hairy Woodpecker.
50. PICUS HARRISII,
Harris' Woodpecker.
51. PICUS PUBESCENS,
Downy Woodpecker.
52. PICUS GAIRDNERI,
Gairdner's Woodpecker.
53. PICUS NUTTALLI,
Nuttall's Woodpecker.
54. PICUS BOREALIS,
Red-cockaded Woodpecker.
55. PICUS ALBOLARVATUS,
White-headed Woodpecker.
56. PICOIDES ARCTICUS,
Three-Toed Woodpecker.
57. PICOIDES HIRSUTUS,
Banded Three-toed Woodpecker.
58. PICOIDES DORSALIS,
Striped three-toed Woodpecker.
59. SPHYROPICUS VARIUS, BAIRD,
Yellow-bellied Woodpecker.
60. SPHYROPICUS NUCHALIS,
Red-Throated Woodpecker.
61. SPHYROPICUS RUBER,
Red-breasted Woodpecker.
62. SPHYROPICUS WILLIAMSONII
Williamson's Woodpecker.
63. HYLOTOMUS PILEATUS,
Black Woodpecker.
64. CENTURUS CAROLINUS,
Red-bellied Woodpecker.
65. CENTURUS FLAVIVENTRIS.Sw
Yellow-bellied Woodpecker.
66. MELANERPES ERYTHROCEPHALUS,
Red-headed Woodpecker.
67. MELANERPES FORMICIVORUS
California Woodpecker.
68. MELANERPES TORQUATUS,
Lewis's Woodpecker.
69. COLAPTES AURATUS,
Yellow-shafted Flicker.
70. COLAPTES MEXICANUS,
Red-shafted Flicker.

ORDER III.—INSESSORES.

PERCHERS.

71. TROCHILUS COLUBRIS,
Humming-Bird.
72. SELASPHORUS RUFUS.
Rufous Humming Bird.
73. PANYPTILA MELANOLEUCA,
White-throated Swift.

74. NEPHOECETES NIGER.
Black Swift.
75. CHAETURA PELASGIA,
Chimney Swallow.
76. CHAETURA VAUXII,
Oregon Swift.
77. ANTROSTOMUS VOCIFERUS,
Whip-poor-will.
78. CHORDEILES POPETUE.
Night-Hawk.
79. CHORDEILES HENRYII,
Western Night Hawk.
80. CERYLE ALCYON,
Belted Kingfisher.
81. MOMOTUS CAERULICEPS,
Saw Bill.
82. TYRANNUS CAROLINENSIS,
King Bird ; Bee Bird.
83. TYRANNUS DOMINICENSIS,
Gray King Bird.
84. TYRANNUS VERTICALIS,
Arkansas Fly-catcher.
85. TYRANNUS MELANCHOLI-
Silent Fly-catcher. [CUS,
86. MYIARCHUS CRINITUS.
Great Crested Fly-catcher.
87. SAYORNIS FUSCUS,
Pewee.
88. SAYORNIS SAYUS,
Say's Fly-catcher.
89. CONTOPUS BOREALIS,
Olive-sided Fly-catcher.
90. CONTOPUS RICHARDSONII,
Short-legged Pewee.
91. CONTOPUS VIRENS,
Wood Pewee.
92. EMPIDONAX TRAILII,
Traill's Fly-catcher.
93. EMPIDONAX PUSILLUS,
Little Fly-catcher.
94. EMPIDONAX MINIMUS,
Least Fly-catcher.
95. EMPIDONAX FLAVIVENTRIS,
Yellow-bellied Fly-catcher.
96. EMPIDONAX DIFFICILIS,
Western Fly-catcher.
97. TURDUS MUSTELINUS,
Wood Thrush.
98. TURDUS PALLASI,
Hermit Thrush.
99. TURDUS SILENS,
Silent Thrush.
100. TURDUS NANUS,
Dwarf Thrush.
101. TURDUS FUSCESCENS,
Wilson's Thrush.
102. TURDUS USTULATUS.
Oregon Thrush.
103. TURDUS SWAINSONII.
Olive-Backed Thrush.
104. TURDUS MIGRATORIUS.
Robin.
105. TURDUS NAEVIUS.
Varied Thrush.
106. SAXICOLA ŒNANTHE,
Stone Chat.
107. SIALIA SIALIS,
Blue Bird.
108. SIALIA MEXICANA,
Western Blue Bird,
109. SIALIA ARCTICA,
Rocky Mountain Blue Bird.
110. REGULUS CALENDULA,
Ruby-crowned Wren.
111. REGULUS SATRAPA,
Golden Crested Wren.
112. REGULUS SATRAPA,
Cuvier's Golden Crest.
113. ANTHUS LUDOVICIANUS,
Tit-lark.
114. MNIOTILTA VARIA,
Black and White Creeper.
115. MNIOTILTA LONGIOSTRIS,
Long-billed Creeper.
116. PARULA AMERICANA,
Blue Yellow-back.
117. PROTONOTARIA CITREA,
Prothonotary Warbler.
118. GEOTHLYPIS TRICHAS,
Maryland Yellow-Throat.
119. GEOTHLYPIS VELATUS,
Gray-headed Warbler.
120. GEOTHLYPIS PHILADELPHIA,
Mourning Warbler.
121. GEOTHLYPIS MACGILLIVRAYI
Macgillivray's Warbler.
122. OPORORNIS AGILIS,
Connecticut Warble.
123. ICTERIA VIRIDIS,
Yellow-breasted Chat.
124. ICTERIA LONGICAUDA.
Long-tailed Chat.
125. HELMITHERUS VERMIVORUS
Worm-eating Warbler.
126. HELMITHERUS SWAINSONII.
Swainson's Warbler.
127. HELMINTHOPHAGA PINUS,
Blue-winged Yellow Warbler.

128. HELMINTHOPHAGA CHRYSOPTERA.
Golden-winged Warbler.
129. HELMINTHOPHAGA BACHMANI,
Bachman's Warbler.
130. HELMINTHOPHAGA RUFICAPILLA,
Nashville Warbler.
131. HELMINTHOPHAGA VIRGINIAE,
Mountain Warbler.
132 HELMINTHOPHAGA CELATA,
Orange-crowned Warbler.
133. HELMINTHOPHAGA PEREGRINA,
Tennessee Warbler.
134. SEIURUS AUROCAPILLUS,
Golden-crowned Thrush.
135. SEIURUS NOVEBORACENSIS,
Water Thrush.
136. DENDROICA VIRENS,
Black-throated Green Warbler.
137. DENDROICA OCCIDENTALIS,
Western Warbler.
138. DENDROICA TOWNSENDII,
Townsend's Warbler.
139. DENDROICA NIGRESCENS,
Black-throated Gray Warbler.
140. DENDROICA CANADENSIS,
Black-throated Blue Warbler.
141. DENDROICA CORONATA,
Yellow-rump Warbler.
142. DENDROICA AUDUBONII,
Audubon's Warbler.
143. DENDROICA BLACKBURNIA,
Blackburnian Warbler.
144. DENDROICA CASTANEA,
Bay-breasted Warbler.
145. DENDROICA PINUS,
Pine-creeping Warbler.
146. DENDROICA MONTANA,
Blue Mountain Warbler.
147. DENDROICA PENNSYLVANICA
Chesnut-sided Warbler.
148. DENDROICA STRIATA,
Black-Poll Warbler.
149. DENDROICA AESTIVA.
Yellow Warbler.
150. DENDROICA MACULOSA,
Black and Yellow Warbler.
151. DENDROICA KIRTLANDII,
Kirtland's Warbler.
152. DENDROICA TIGRINA,
Cape May Warbler.
153. DENDROICA CARBONATA,
Carbonated Warbler.
154. DENDROICA SUPERCILIOSA
Yellow-throated Warbler.
155. DENDROICA DISCOLOR,
Prairie Warbler.
156. MYIODIOCTES MITRATUS,
Hooded Warbler.
157. MYIODIOCTES PUSILLUS,
Small-headed Fly-catcher.
158. MYIODIOCTES CANADENSIS,
Canada Fly-catcher.
159. MYIODIOCTES BONAPARTII,
Bonaparte's Fly-catcher.
160. SETOPHAGA RUTICILLA,
Redstart.
161. PYRANGA RUBRA,
Scarlet Tanager.
162. PYRANGA AESTIVA,
Summer Red Bird.
163. PYRANGA HEPATICA,
Rocky Mountain Tanager.
164. HIRUNDO HORREORUM,
Barn Swallow.
165. HIRUNDO LUNIFRONS,
Cliff Swallow.
166. HIRUNDO BICOLOR,
White-billed Swallow.
167. COTYLE RIPARIA,
Bank Swallow.
168. COTYLE SERRIPENNIS,
Rough-winged Swallow.
169. PROGNE PURPUREA,
Purple Martin.
170. AMPELIS GARRULUS,
Wax Wing.
171. AMPELIS CEDRORUM.
Cedar Bird.
172. PHAINOPEPLA NITENS,
Black-crested Flycatcher.
173. MYIADESTES TOWNSENDII,
Townsend's Flycatcher.
174. COLLYRIO BOREALIS,
Great Northern Shrike.
175. COLLYRIO LUDOVICIANUS,
Loggerhead Shrike.
176. COLLYRIO EXCUBITOROIDES,
White-rumped Shrike.
177. VIREO OLIVACEUS,
Red-eyed Flycatcher.

178. VIREO FLAVOVIRIDIS,
Yellow-green Vireo.
179. VIREO GILVUS,
Warbling Flycatcher.
180. VIREO BELLI,
Bell's Vireo.
181. VIREO ATRICAPILLUS,
Black-headed Flycatcher.
182. VIREO NOVEBORACENSIS,
White-eyed Vireo.
183. VIREO SOLITARIUS,
Blue-headed Flycatcher.
184. VIREO CASSINII,
Cassin's Vireo.
185. VIREO FLAVIFRONS,
Yellow-throated Flycatcher.
186. MIMUS CAROLINENSIS,
Cat Bird.
187. HARPORHYNCHUS RUFUS,
Brown Thrush.
188. HARPORHYNCHUS LONGICAUDA,
Long-tailed Thrush.
189. CISTOTHORUS PALUSTRIS,
Long-billed Marsh Wren.
190. CISTOTHORUS STELLARIS,
Short-billed Marsh Wren.
191. TROGLODYTES AEDON,
House Wren.
192. TROGLODYTES AMERICANUS,
Wood Wren.
193. TROGLODYTES HYEMALIS,
Winter Wren.
194. CERTHIA AMERICANA,
American Creeper.
195. SITTA CAROLINENSIS,
White-bellied Nuthatch.
196. SITTA CANADENSIS,
Red-bellied Nuthatch.
197. POLIOPTILLA PLUMBEA,
Western Gnatcatcher.
198. POLIOPTILLA MELANURA,
Black-tailed Gnatcatcher.
199. LOPHOPHANES ATRICRISTATUS,
Black-crested Tit.
200. PARUS SEPTENTRIONALIS,
Long-tailed Chickadee.
201. PARUS ATRICAPILLUS,
Black-cap Titmouse.
202. PARUS OCCIDENTALIS,
Western Titmouse.
203. PARUS RUFESCENS,
Chestnut-backed Tit.
204. PARUS HUDSONICUS,
Hudsonian Titmouse.
205. PSALTRIPARUS MINIMUS,
Least Tit.
206. CERTHIOLA FLAVEOLA,
Yellow-Rumped Creeper.
207. EREMOPHILA CORNUTA,
Sky Lark.
208. HESPERIPHONA VESPERTINA
Evening Grosbeak.
209. PINICOLA CANADENSIS,
Pine Grosbeak.
210. CARPODACUS PURPUREUS,
Purple Finch.
211. CARPODACUS CALIFORNICUS
Western Purple Finch.
212. CARPODACUS CASSINII,
Cassin's Purple Finch.
213. CARPODACUS FRONTALIS,
House Finch.
214. CHRYSOMITRIS STANLEYI,
Stanley's Goldfinch.
215. CHRYSOMITRIS TRISTIS,
Yellow Bird.
216. CHRYSOMITRIS PSALTRIA,
Arkansas Finch.
217. CHRYSOMITRIS PINUS,
Pine Finch.
218. CURVIROSTRA AMERICANA,
Red Crossbill.
219. CURVIROSTRA LEUCOPTERA,
White-winged Crossbill.
220. AEGIOTHUS LINARIA,
Lesser Red Poll.
221. AEGIOTHUS CANESCENS,
Mealy Red Poll.
222. LEUCOSTICTE TEPHROCOTIS,
Gray-crowned Finch.
223. LEUCOSTICTE ARCTOUS,
Arctic Finch.
224. PLECTROPHANES NIVALIS,
Snow Bunting.
225. PLECTROPHANES LAPPONICUS
Lapland Longspur.
226. PLECTROPHANES ORNATUS,
Chestnut-collared Bunting.
227. PLECTROPHANES MACCOWNII
Maccown's Longspur.
228. CENTRONYX BAIRDII,
Baird's Bunting.

229. PASSERCULUS SAVANNA,
Savannah Sparrow.
230. PASSERCULUS SANDWICHEN-
Nootka Sparrow. [SIS,
231. PASSERCULUS ALAUDINUS,
Lark Sparrow.
232. PASSERCULUS ROSTRATUS,
Beaked Sparrow.
233. POOECETES GRAMINEUS,
Grass Finch.
234. COTORNICULUS PASSERINUS,
Yellow-winged Sparrow.
235. ZONOTRICHIA LEUCOPHRYS,
White-crowned Sparrow.
236. ZONOTRICHIA CORONATA,
Golden-crowned Sparrow.
237. ZONOTRICHIA ALBICOLLIS,
White-throated Sparrow.
238. JUNCO HYEMALIS,
Black Snow Bird.
239. POOSPIZA BILINEATA,
Black-throated Sparrow.
240. POOSPIZA BELLI,
Bell's Finch.
241. SPIZELLA MONTICOLA,
Tree Sparrow.
242. SPIZELLA PUSILLA,
Field Sparrow.
243. SPIZELLA SOCIALIS,
Chipping Sparrow.
244. SPIZELLA PALLIDA,
Clay-colored Bunting.
245. SPIZELLA BREWERI,
Brewer's Sparrow.
246. MELOSPIZA MELODIA,
Song Sparrow.
247. MELOSPIZA GOULDII,
Gould's Sparrow.
248. MELOSPIZA RUFINA,
Rusty Song Sparrow.
249. MELOSPIZA FALLAX,
Mountain Song Sparrow.
250. MELOSPIZA LINCOLNII,
Lincoln's Finch.
251. MELOSPIZA PALUSTRIS,
Swamp Sparrow.
252. PEUCAEA AESTIVALIS,
Bachman's Finch.
253. PASSERELLA ILIAC,
Fox-colored Sparrow.
254. PASSARELLA TOWNSENDII,
Oregon Finch.
255. CALAMOSPIZA BICOLOR,
Lark Bunting.
256. EUSPISA AMERICANA,
Black-throated Bunting.
257. EUSPIZA TOWNSENDII,
Townsend's Bunting.
258. GUIRACA LUDOVICIANA,
Rose-Breasted Grosbeak.
259. GUIRACA MELANOCEPHALA,
Black-headed Grosbeak.
260. GUIRACA CAERULEA,
Blue Grosbeak.
261. CYANOSPIZA CYANEA.
Indigo Bird.
262. CARDINALIS VIRGINIANUS,
Red Bird.
263. PIPILO ERYTHROPTHALMUS,
Ground Robin; Towhee.
264. PIPILO OREGONUS,
Oregon Ground Robin.
265. PIPILO ARCTICUS,
Arctic Towhee.
266. PIPILO FUSCUS,
Brown Towhee.
267. DOLICHONYX ORYZIVORUS,
Boblink; Reed Bird.
268. MOLOTHRUS PECORIS,
Cow Bird.
269. AGELAIUS PHOENICEUS,
Red-winged Blackbird.
270. AGELAIUS GUBERNATOR,
Red-shouldered Blackbird.
271. AGELAIUS TRICOLOR,
Red and White-shouldered Blackbird.
272. XANTHOCEPHALUS ICTERO-
CEPHALIS,
Yellow-headed Blackbird.
273. STURNELLA MAGNA,
Meadow Lark.
274. STURNELLA NEGLECTA,
Western Lark.
275. ICTERUS SPURIUS,
Orchard Oriole.
276. ICTERUS BALTIMORE,
Baltimore Oriole.
277. ICTERUS BULLOCKII,
Bullock's Oriole.
278. SCOLECOPHAGUS FERRUGI-
NEUS,
Rusty Blackbird.

279. SCOLECOPHAGUS CYANOCEPHALUS,
Brewer's Blackbird.
280. QUISCALUS MACROURA,
Long-tailed Grakle.
281. QUISCALUS MAJOR,
Boat-tailed Grakle.
282. QUISCALUS VERSICOLOR,
Crow Blackbird.
283. CORVUS CARNIVORUS,
American Raven.
284. CORVUS CACALOTI,
Colorado Raven.
285. CORVUS AMERICANUS,
Common Crow.
286. CORVUS CAURINUS,
Western Fish Crow.
287. CORVUS OSSIFRAGUS,
Fish Crow.
288. CYANURA CRISTATA,
Blue Jay.
289. CYANURA STELLERI,
Steller's Jay.
290. CYANOCITTA CALIFORNICA,
California Jay.
291. PERISOREUS CANADENSIS,
Canada Jay.

ORDER IV.—RASORES.

SCRATCHERS.

292. ECTOPISTES MIGRATORIA,
Wild Pigeon.
293. ZENAIDURA CAROLINENSIS,
Common Dove.
294. CHAMAEPELIA PASSERINA,
Ground Dove.
295. TETRAO CANADENSIS,
Spruce Partridge.
296. CENTROCERCUS UROPHASIANUS,
Sage Cock.
297. PEDIOECETES PHASIANELLUS
Sharp-tailed Grouse.
298. CUPIDONIA CUPIDO,
Prairie Hen.
299. BONASA UMBELLUS,
Ruffed Grouse.
300. Var. BONASA UMBELLOIDES,
Gray Mountain Grouse.
301. BONASA SABINII,
Oregon Grouse.
302. LAGOPUS ALBUS,
White Ptarmigan.
303. LAGOPUS RUPESTRIS.
Rock Grouse.
304. LAGOPUS LEUCURUS,
White-tailed Ptarmigan.
305. LAGOPUS AMERICANUS,
American Ptarmigan.
306. ORTYX VIRGINIANUS,
Partridge; Quail.

ORDER V.—GRALLATORES

WADERS.

307. GRUS AMERICANUS,
Whooping Crane.
308. GRUS CANADENSIS,
Sandhill Crane.
309. HERODIAS EGRETTA,
White Heron.
310. ARDEA HERODIAS,
Great Blue Heron.
311. ARDETTA EXILIS,
Least Bittern.
312. BOTAURUS LENTIGINOSUS,
Bittern; Stake-Driver.
313. BUTORIDES VIRESCENS,
Green Heron.
314. NYCTIARDEA GARDENI,
Night Heron.
315. CHARADRIUS VIRGINICUS,
Golden Plover.
316. AEGIALITIS VOCIFERUS,
Killdeer.
317. AEGIALITIS WILSONIUS,
Wilson's Plover.
318. AEGIALITIS SEMIPALMATUS,
Semipalmated Plover.
319. AEGIALITIS MELODUS,
Piping Plover.

320. AEGIALITIS NIVOSUS.
Western Plover.
321. SQUATAROLA HELVETICA,
Black-bellied Plover.
322. HAEMATOPUS PALLIATUS,
Oyster-catcher.
323. STREPSILAS INTERPRES,
Turnstone.
324. STREPSILAS MELANOCE-
Black Turnstone. [PHALA,
325. RECURVIROSTRA AMERICANA
American Avoset.
326. HIMANTOPUS NIGROCILLIS,
Black-necked Stilt.
327. PHALAROPUS WILSONII,
Wilson's Phalarope.
328. PHALAROPUS HYPERBOREUS
Northern Phalarope.
329. PHALARUS FULICARIUS,
Red Pharalope.
330. PHILOMELA MINOR.
American Woodcock.
331. MACROHAMPHUS GRISEUS,
Red-breasted Snipe.
332. MACRORHAMPHUS SCOLO-
PACEUS,
Greater Longbeak.
333. TRINGA CANUTUS,
Knot.
334. TRINGA MARITIMA,
Purple Sandpiper.
335. TRINGA ALPINA, var. AMERI-
CANA.
Red-backed Sandpiper.
336. TRINGA MACULATA,
Jack-Snipe.
337. TRINGA WILSONII,
Least Sandpiper.
338. TRINGA BONAPARTII,
Bonaparte's Sandpiper.
339. CALIDRIS ARENARIA,
Sanderling.
340. EREUNETES PETRIFICATUS.
Semipalmated Sandpiper.
341. MICROPALAMA HIMANTOPUS
Stilt Sandpiper.
342. SYMPHEMIA SEMIPALMATA,
Willet.
343. GAMBETTA MELANOLEUCA,
Tell-Tale; Stone Snipe.
344. GAMBETTA FLAVIPES,
Yellow-legs.
345. RHYACOPHILUS SOLITARIUS.
Solitary Sandpiper.
346. TRINGOIDES MACULARIUS,
Spotted Sandpiper.
347. ACTITURUS BARTRAMIUS,
Field Plover.
348. TRYNGITES RUFESCENS,
Buff-breasted Sandpiper.
349. LIMOSA FEDOA.
Marbled Goodwit.
350. LIMOSA HUDSONICA,
Hudson Goodwit.
351. NUMENIUS LONGISOSTRIS,
Long-billed Curlew.
352. NUMENIUS HUDSONICA,
Long-billed Curlew.
353. NUMENIUS BOREALIS,
Esquimaux Curlew.
354. RALLUS ELEGANS,
Marsh Hen.
355. RALLUS CREPITANS,
Clapper Rail.
356. RALLUS VIRGINIUS,
Virginia Rail.
357. PORZANA CAROLINA.
Common Rail.
358. PORZANA JAMAICENSIS,
Little Black Rail.
359. PORZANA NOVEBORACENSIS,
Yellow Rail.
360. CREX PRATENSIS.
Corn-crake.
361. FULICA AMERICANA,
Coot.
362. GALLINULA MARTINICA,
Purple Gallinule.

ORDER VI.—NATATORES.

SWIMMERS.

363. CYGNUS AMERICANUS,
American Swan.
364. CYGNUS BUCCINATOR,
Trumpeter Swan.
365. ANSER ALBATUS,
White Goose.

366. ANSER CAERULESCENS,
White-headed Goose.

367. ANSER GAMBELII,
White-fronted Goose.

368. ANSER FRONTALIS,
Brown-fronted Goose.

369. BERNICLA CANADENSIS,
Canada Goose.

370. BERNICLA OCCIDENTALIS,
Western Goose.

371. BERNICLA LEUCOPAREIA,
White-cheeked Goose.

372. BERNICLA HUTCHINSII,
Hutchin's Goose.

373. BERNICLA BRENTA,
Brant.

374. DENDROCYGNA FULVA,
Brown Tree-duck.

375. ANAS BOSCHAS.
Mallard.

376. ANAS OBSCURA,
Black Duck.

377. DAFFILA ACUTA.
Sprig-tail; Pin-tail.

378. NETTION CAROLINENSIS,
Green-winged Teal.

379. QUERQUEDULA DISCORS.
Blue-winged Teal.

380. SPATULA CLYPEATA,
Shoveller.

381. CHAULELASMUS STREPERUS,
Gadwall.

382. MARECA AMERICANA.
Baldpate.

383. MARECA PENELOPE,
Widgeon.

384. AIX SPONSA,
Summer Duck.

385. FULIX MARILA,
Greater Black-head.

386. FULIX AFFINIS,
Little Black-head.

387. AYTHYA AMERICANA,
Red-head.

388. ATHYA VALLISNERIA,
Canvass-back.

389. BUCEPHALA AMERICANA.
Golden Eye.

390. BUCEPHALA ISLANDICA.
Barrow's Golden Eye.

391. BUCEPHALA ALBEOLA,
Butter-ball.

392. HISTRONICUS TORQUATTS,
Harlequin Duck.

393. HARELDA GLACIALIS,
South Southerly.

394. POLYSTICTA STELLERI,
Steller's Ducks.

395. CAMPTOLAEMUS LABRADORIUS,
Labrador Duck.

396. MELANETTA VELVETINA,
Velvet Duck.

397. PELIONETTA PERSPICILLATA,
Surf Duck.

398. OIDEMIA AMERICANA,
Scoter.

399. OIDEMIA BIMACULATA,
Huron Scoter.

400. SOMATERIA MOLLISSIMA,
Eider Duck,

401. SOMATERIA V. NIGRA,
Pacific Eider.

402. SOMATERIA SPECTABILIS,
King Eider.

403. ERISMATURA RUBIDA,
Ruddy Duck.

404. ERISMATURA DOMINICA.
Black Masked Duck.

405. MERGUS AMERICANUS,
Sheldrake.

406. MERGUS SERRATOR,
Red-breasted Merganser.

407. LOPHODYTES CUCULLATUS,
Hooded Merganser.

408. PELECANUS ERYTHRORHYNCUS,
American Pelican.

409. PELECANUS FUSCUS,
Brown Pelican.

410. SULA BASSANA,
Gannet.

411. GRACULUS CARBO,
Common Cormorant.

412. GRACULUS DILOPHUS,
Double-crested Cormorant.

413. GRACULUS PENICILLATUS,
Brandt's Cormorant.

414. GRACULUS VIOLACEUS,
Violet Green Cormorant.

415. THALASSIDROMA LEACHII.
Leach's Petrel.

416. THALASSIDROMA MELANIA,
Black Stormy Petrel.
417. THALASSIDROMA WILSONI,
Wilson's Petrel.
418. THALASSIDROMA PELAGICA,
Mother Cary's Chicken.
419. PUFFINUS OBSCURUS,
Dusky Shearwater.
420. STERCORARIUS CATARRACTES
Common Skua.
421. STERCORARIUS POMARINUS,
Pomarine Skua.
422. STERCORARIUS PARASITICUS,
Arctic Skua.
423. STERCORARIUS CEPPHUS,
Buffon's Skua.
424. LARUS GLAUCESCENS,
Glaucous-winged Gull.
425. LARUS LEUCOPTERUS,
White-winged Gull.
426. LARUS CHALCOPTERUS,
Gray-winged Gull.
427. LARUS MARINUS,
Great Black-backed Gull.
428. LARUS ARGENTATUS,
Herring Gull.
429. LARUS OCCIDENTALIS,
Western Gull.
430. LARUS CALIFORNICUS,
California Gull.
431. LARUS BRACHYRHYNCHUS,
Short-billed Gull.
432. BLASIPUS HEERMANNI,
White-headed Gull.
433. CHROICOCEPHALUS ATRICILLA,
Laughing Gull.
434. CHROICOCEPHALUS FRANKLINII,
Franklin's Rosy Gull.
435. CHROICOCEPHALUS PHILADELPHIA,
Bonaparte's Gull.
436. CHROICOCEPHALUS MINUTUS,
Littte Gull.
437. RISSA TRIDACTYLA,
Kittiwake Gull.
438. RISSA SEPTENTRIONALIS,
North Pacific Kittiwake.
439. RISSA BREVIROSTRIS,
Short-billed Kittiwake.
440. RISSA NIVEA,
Yellow-billed Gull,
441. PAGOPHILA EBURNEA,
Ivory Gull.
442. CREAGRUS FURCATUS,
Swallow-tailed Gull.
443. XEMA SABINII.
Fork-tailed Gull.
444. STERNA ARANEA,
Marsh Tern.
445. STERNA CASPIA,
Caspian Tern.
446. STERNA REGIA,
Royal Tern.
447. STERNA ELEGANS,
Elegant Tern.
448. STERNA ACUFLAVIDA,
Cabot's Tern.
449. STERNA FULIGINOSA,
Sooty Tern.
450. STERNA WILSONI,
Wilson's Tern.
451. STERNA MACROURA,
Arctic Tern.
452. STERNA FORSTERI,
Forster's Tern.
453. STERNA PARADISEA,
Roseate Tern.
454. STERNA PIKEI,
Slender-billed Tern.
455. STERNA FRENATA,
Least Tern.
456. HYDROCHELIDON PLUMBEA,
Short-tailed Tern,
457. ANOUS STOLIDUS,
Noddy Tern.
458. RHYNCHOPS NIGRA,
Black Skimmer.
459. COLYMBUS TORQUATUS,
Loon.
460. COLYMBUS ARCTICUS,
Black-throated Diver.
461. COLYMBUS PACIFICUS,
Pacific Diver.
462. COLYMBUS SEPTENTRIONALIS,
Red-throated Diver.
463. PODICEP'S GRISEIGENA,
Red-Necked Grebe.
464. PODICEP'S CRISTATUS,
Crested Grebe,

465. PODICEPS OCCIDENTALIS,
Western Grebe.
466. PODICEPS CORNUTUS,
Horned Grebe.
467. PODICEPS CALIFORNICUS,
California Grebe.
468. PODICEPS AURITUS,
Eared Grebe.
469. ALCA TORDA,
Razor-billed Auk.
470. MORMON CIRRHATA,
Tufted Puffin.
471. MORMON ARCTICA,
Arctic Puffin.
472. PHALERIS CAMTSCHATICA,
Kamtschatkan Auk.
473. PHALERIS PUSILLA,
Least Auk.
474. URIA GRYLLE,
Black Guillemot.
475. URIA COLUMBA,
Western Guillemot.
476. URIA CARBO,
Crow Guillemot.
477. URIA LOMVIA,
Foolish Guillemot.
478. URIA RINGVIA,
Murre.
479. BRACHYRHAMPHUS MARMORATUS,
Marbled Guillemot.
480. BRACHYRHAMPHUS WRANGELII,
Wrangel's Guillemot.
481. MERGULUS ALLE,
Sea Dove.

B. B. R. A. S.

35

Not to be kept more than days.

"	Ross (Dr. A. M.)—Catalogue to illustrate the Animal Resources of the Dominion of Canada at the U. S. Centennial Exhibition. ...	1	Pht

First issued on the *Vol.*

Names of Applicants.	Issued.		Returned.	

ON THE BREEDING-HABITS, NEST, AND EGGS, OF THE WHITE-TAILED PTARMIGAN (LAGOPUS LEUCURUS).

By Dr. Elliott Coues, U. S. Army.

Very little having been placed on record respecting the breeding-habits, nest, and eggs of *Lagopus leucurus*, the present occasion is taken to bring together the information we possess on the subject, and supplement it with a more precise account, the result of an examination of a set of eggs which, with the nest, were collected during the summer of 1875 by one of Dr. Hayden's parties, and submitted to my inspection.

The White-tailed Ptarmigan is interesting as the southernmost species of the genus *Lagopus*, and the only one of any considerable latitudinal dispersion in the United States. The Willow Ptarmigan (*L. albus*) is indeed recorded from some points along our northern frontier, but even there its occurrence has only been noted in winter. *L. leucurus* alone breeds within the United States (exclusive of Alaska). It is one of the later additions to the genus, having remained unknown to naturalists up to the year 1831, when it was described and figured by Swainson and Richardson in the second volume of the *Fauna Boreali-Americana* (p. 356, pl. 63), from six specimens procured by Mr. Drummond and Mr. Macpherson in the Rocky Mountains, latitude 54° to 63° north. Mr. David Douglas had killed several in 1827, but these were destroyed. It is only within the last few years that we have become fairly well acquainted with the bird. The species is readily distinguished from its allies by the character implied in the name; the tail-feathers being pure white, like the rest of the plumage in winter.

Its known range in the United States has lately been extended to latitude 37° north; the species having been found at Cantonment Burgwyn, New Mexico, by Dr. B. J. D. Irwin, United States Army.* In longitudinal distribution, it is confined to the Rocky Mountains and some other high ranges in the West.

The earliest account of the nest or eggs which I have at hand is that given by Mr. C. E. Aiken,† who states that the bird is said to be common on the Snowy Range of Colorado Territory, and who describes the nest, upon the authority of a miner, as composed of leaves and grass, upon the ground, among bushes. The eggs in this case were said to have been fourteen in number, and "light bluish-brown, spotted with dark-brown," in color.

The first egg known to me to have been examined by a naturalist was an imperfect one taken by Mr. A. G. Mead, who procured it on Mount Lincoln, Colorado Territory, and by him presented to Mr. J. A. Allen, who kindly furnished me a short description, which I published in the account of the species given in the "Birds of the Northwest" (p. 426). According to Mr. Allen, it was "thickly sprinkled with small, bright

* Coues, Proc. Acad. Nat. Sci. Phila. 1866, p. 94.
† Proc. Bost. Soc. Nat. Hist. xv, 1872, p. 209.

reddish-brown dots, on a chocolate-colored ground, and measured about 2.00 inches in length by 1.20 inches in diameter". This same egg was also described by Dr. T. M. Brewer, in Baird, Brewer, and Ridgway, History of North American Birds, iii, 1874, p. 465.

The first account of the particular habits of the bird during the breeding-season was likewise communicated to me by another esteemed correspondent, Mr. T. Martin Trippe, C. E., who appears to have enjoyed excellent opportunities for observation among the mountains of Clear Creek County, Colorado Territory. "The Ptarmigan builds its nest," says Mr. Trippe, "in the latter part of June, and commences hatching toward the close of the month or early in July. The nest—which is always on or near the summit of a ridge or spur, many hundred feet above timber-line—is merely a depression in the ground, lined with a few straws, and white feathers from the mother's breast. The eggs are eight in number, of a light buff-brown, thickly sprinkled with spots of dark chocolate-brown, somewhat thicker at the larger end. While on her nest, the bird is very tame. Once while walking near the summit of the range, I chanced to look down, and saw a Ptarmigan in the grass, at my very feet—at the next step I should have trodden upon her. Seeing that she did not appear frightened, I sat down gently, stroked her on the back, and finally, putting both hands beneath her, raised her gently off the nest and set her down on the grass, while she scolded and pecked at my hands like a setting hen, and, on being released, merely flew a few yards and settled on a rock, from which she watched me till I went away. Late in July, I came across a brood of young ones, apparently not more than four or five days old. They were striped with broad bands of white and blackish-brown, and looked precisely like little game chickens. The mother flew in my face and hit me with her wings, using all the little artifices that the Quail and Partridge know so well how to employ, to draw me away; while her brood, seven or eight in number, nimbly ran and hid themselves in the dense grass and among the stones. On another excursion above timber-line, toward the close of August, I found most of the young ones nearly grown and strong on the wing; but one brood was of the size of Quails, showing that some birds must begin breeding much later than others, or that they occasionally raise two broods."—(Birds of the Northwest, p. 427.)

In the Proceedings of the Boston Society of Natural History, vol. xvi, p. 348 (1874), Dr. T. M. Brewer describes the fragments of a set of eggs received from Mr. T. M. Trippe, whose MSS. notes accompanying, published by Dr. Brewer, are to the same effect as those already quoted from the "Birds of the Northwest"; having apparently been drawn up from the same incident. This set of eggs was found June 28, 1873, on a high ridge a thousand feet above timber-line, near the Chicago Lakes, about fifteen miles from Idaho Springs, Colorado Territory. One of the eggs, though much damaged, admitted of being put together sufficiently to show its size, shape, and in fact all its characters. It is thus described by Dr. Brewer: "This egg is 1.70 inches in length by 1.21 in breadth; is oval in shape, one end being but very little smaller than the other. The ground-color is a rich creamy-drab, and the surface of the egg is pretty uniformly marked with small rounded dots of dark chestnut; these are about equally distributed over the entire egg, and are nowhere confluent."

A further contribution to the history of the species was made by Mr. J. H. Batty in the *Forest and Stream* (newspaper) of January 29, 1874. The writer has, however, little to say of the breeding-habits, and, as is now clearly seen, was in error in his supposition that the bird lays only

three or four eggs, having reasoned upon insufficient premises, as well as in the face of all analogy bearing upon the reproduction of species in this family of birds.

The material which forms the especial subject of this article consists of a nest and four eggs.

I am not informed that this number of eggs is to be considered as the nest-complement; nor is there any reason to believe that the clutch, had it been completed, would not have consisted of a greater number.

The specimens were taken by Mr. A. D. Wilson, topographer of the Southwest Division of Dr. Hayden's Survey, on the 15th of July, 1875, in the Sierra San Juan, Southern Colorado, near the headwaters of the Rio Grande del Norte, eleven miles southwest of Antelope Park, on a rocky plateau, at an altitude of about 12,400 feet. They are deposited in the National Museum, Smithsonian Institution, being No. 17200, S. I. Register. The authentication and identification are absolute; and the specimens are the first perfect ones which have been seen in any collection—as far as the writer's information goes.

The nest, in its present state, measures scarcely five inches in diameter by about an inch in depth. It thus seems rather small for the size of the bird, but is probably somewhat compressed in transportation. The shape is saucer-like, but with very little concavity of surface. The bottom is decidedly and regularly convex in all directions, apparently fitting a considerable depression in the ground. The outline is, to all intents, circular. The nest is rather closely matted, the material interlacing in all directions, and retains considerable consistency. The material is chiefly fine dried grass-stems; with these are mixed, however, a few small leaves and weed-tops, and quite a number of feathers. The latter—evidently those of the parent birds—are embedded throughout the substance of the nest, though more numerous upon its surface, where a dozen or so are deposited; there may have been some loose ones lost in handling.

The account of the color of the eggs, given by Mr. Aiken upon impersonal authority as "light bluish-brown", is altogether wrong. Nor does the color of the specimens before me seem to my eye to agree with the expression used by Mr. Allen respecting his specimen—"chocolate-colored". Dr. Brewer's phrase—"rich creamy drab"—is just about the mark, though I hardly perceive a shade of the color to which I attach the name drab. However, "drab" and "dun" are indefinite terms. I should say, simply, that the ground is dull cream-color; and in selecting this term I have the advantage of the opinion of an expert colorist. The general complexion of the egg is very notably different from that of the eggs of either *L. albus* or *L. rupestris*, owing to the much fewer and smaller spots. In the species just mentioned, the markings are so strong and so numerous that they confer the general tone; and it is difficult to render an ordinary pen-and-ink stroke legible. In the present case of *L. leucurus*, the ground-color is as evident as the markings, and the inscription on the shell is perfectly plain.

The markings are all small, for the most part sharp and distinct,—the occasional overlapping of the spots producing in no case a blotch of any considerable size—mostly rounded in contour, to all intents distributed evenly over the whole surface, and, of course, innumerable in number. Very few of the spots exceed a large pin's head in magnitude; the more conspicuous ones are of about such size, while numberless others are dots or mere points. The color of all the markings is the same, though the larger ones seem of a slightly darker shade than the others, simply because the pigment is laid on more heavily. This

color is dark burnt-sienna, approaching to umber-brown. "Chocolate," "mahogany," "chestnut," are all more familiar terms, which might be used to suggest the color. The markings are all superficial—none appear to be overlaid by shell-substance.

In shape, these eggs are very perfectly ovoidal, without notable pointedness at the smaller end or special flatness at the other; the greatest diameter being nearly across the middle. Three of the specimens measure as follows (the fourth being defective at the point): No. 1, 1.70 × 1.15; No. 2, 1.70 × 1.14; No. 3, 1.68 × 1.11 (inches and decimals).

The shell is smooth to the touch. Seen under a strong lens (Tolles's ½-inch triplet), the surface resembles polished marble, consisting of irregularly-shaped, smooth-edged prominences, betwixt which are innumerable small circular pits or pores.

SOME ACCOUNT, CRITICAL, DESCRIPTIVE, AND HISTORICAL, OF ZAPUS HUDSONIUS.

By Dr. Elliott Coues, U. S. Army.

Having occasion to inspect specimens of this quadruped, collected under the direction of Professor Hayden, I have been led into a further investigation of the species, and have examined the whole of the material contained in the National Museum, Smithsonian Institution, as well as a considerable portion of the literature bearing upon the subject. The present brief article, sketched with pleasure at Professor Hayden's request, is incidental to three main points determined, namely :—

I. There is at present only one known species of *Zapus*.

II. The animal, usually referred to the *Muridæ*, differs from the *Muridæ* to a degree warranting the recognition of a family *Zapodidæ*. Such appreciation of the characters afforded was made in 1872 by Dr. Gill, who erected a family (*Jaculidæ*) for its reception. I may here allude to the presence of an upper premolar, not found in *Muridæ* proper; the different and peculiar construction of the anteorbital foramen; and the saltatorial development of the hind limbs. These and other characters are amplified beyond.

III. None of the various generic names which have been applied to *Zapus hudsonius* are tenable according to recognized rules of nomenclature. Of these, *Dipus* and *Gerbillus* are too obviously inapplicable to require comment. *Jaculus* of Wagler (1830) belongs here; but the name had been used before in an entirely different connection. *Meriones* is in similar case; its original application by Illiger was to another type. Though it was subsequently transferred by Frédéric Cuvier to the present animal (Illiger's being already provided with a name), it cannot stand in this connection; for no synonym of one genus shall become the tenable name of another. A new name, therefore, being required, *Zapus** is proposed; the introduction of the term, of course, necessitating corresponding change in the appellation of the family.

Family ZAPODIDÆ.

< *Subfamily Dipodinæ*, Baird, M. N. A. 1857, 428.
= *Family Jaculidæ*, Gill, Arrangement of the Families of Mammals, 1872, 20.

Genus ZAPUS, Coues. (*g. n.*)

Dipus, sp.; *Gerbillus*, sp., Aliq.
Meriones, F. Cuvier, Dents des Mammifères, 1825 ?, p. —.—Audubon & Bachman, Q. N. A. ii, 1851, 251. *Not of Illiger*, 1811.
Jaculus, Wagler, Syst. Amph. 1839, 30.—Baird, M. N. A. 1857, 429. *Not of Jarocki.*

* Etym. *Za*, augmentative particle, and πους, pes.—This very pat name was suggested to the writer by Dr. Gill, who, however, considers the name *Meriones* to be tenable for this genus.

ZAPUS HUDSONIUS, Coues.

Synonymy.

Dipus hudsonius, ZIMMERMANN, Geog. Gesch. ii, 1780, 358, No. 268 (based on the Long-Legged Mouse of Hudson's Bay, of Pennant).
BODDÆRT, Elench. Anim. i, 1784, 115 (based on Zimmermann).
"SCHREBER, Säug. , 861, No. 6."
FISCHER, Syn. Mamm. 1829, 340 (based on Zimmermann).
Gerbillus hudsonius, RAFINESQUE, Am. Month. Mag. 1818, 446.
LESSON, Man. i, 1827, 257.
Meriones hudsonicus, AUDUBON & BACHMAN, Q. N. A. ii, 1851, 251, pl. 85.
Jaculus hudsonius, BAIRD, M. N. A. 1857, 430, pl. 21, f. 5*a-e*.
NEWBERRY, P. R. R. Rep. vi, 1857, 59 (California).
BAIRD, P. R. R. Rep. x, 1859, Gunnison's & Beckwith's Routes, Mamm. p. 8.
COOPER & SUCKLEY, Nat. Hist. Wash. Terr. 1860, 83, 101, 127.
HAYDEN, Trans. Amer. Philos. Soc. xii, 1862, 147 (Fort Union).
SAMUELS, Ninth Ann. Rep. Mass. Board Agric. 1862, 178 (habits).
GILPIN, Proc. & Trans. Nova Scotia Inst. ii, 1870, 60 (Nova Scotia).
ALLEN, Bull. Mus. Comp. Zool. i, 1870, 226 (Massachusetts).
TENNEY, Am. Nat. vi, 1872, 330, f. 101 (habits).
MERRIAM, U. S. Geol. Surv. Terr. 1872, 665.
AMES, Bull. Minn. Acad. i, 1874, 70 (Minnesota).
ALLEN, Bull. Ess. Inst. vi, 1874, 60, 65 (Wyoming and Utah).
Mus longipes, ZIMMERMANN, Penn. Arktische Zool. i, 1787, 131 (erroneous identification with *Mus longipes* auct.).
Mus canadensis, "PENNANT" (mere Latin rendering of "Canada rat"?).
Dipus canadensis, DAVIES, Trans. Linn. Soc. iv, 1798, 155, pl. 8, f. 5, 6 ("Jumping Mouse of Canada").
SHAW, Gen. Zool. ii, 1801, 192, pl. 161 (after Davies).
TURTON, Syst. Nat. i, 1806, 100.
ORD, Guthrie's Geog. 2d Am. ed. 1815, 292.
FISCHER, Syn. Mamm. 1829, 339.
Gerbillus canadensis, DESMAREST, Mamm. ii, 1822, 331.
HARLAN, Fn. Amer. 1825, 155.
GODMAN, Am. Nat. Hist. ii, 1st ed. 1826, p. —; 2d ed. 1831, 94, pl. —; 3d ed. 1861, 94.
GRIFFITH, Anim. Kingd. v, 1827, 240, No. 624.
EMMONS, Mass. Rep. 1840, 69.
THOMPSON, Nat. Hist. Vermont, 1853, 44.
HALL, Canad. Nat. & Geol. vi, 1861, 304 (Montreal).
Meriones canadensis, LESS., Man. i, 1827, 258.
SCHINZ, Syn. Mamm. ii, 1845, 91.
Dipus americanus, BARTON, Amer. Philos. Trans. iv, 1799, 115, pl. —; vi, 1804, 143.
ORD, Guthrie's Geog. 2d Am. ed. 1815, 292.
Jaculus americanus, WAGLER, Syst. Amphib. 1830, 23.
Meriones americanus, DEKAY, N. Y. Zool. i, 1842, 70, pl. 24, f. 2.
Dipus labradorius, TURTON, Syst. Nat. i, 1806, 99 (Labrador Rat of Pennant).
ORD, Guthrie's Geog. 2d Am. ed. 1815, 292.
Mus labradorius, J. SABINE, App. Frankl. Journ. 1823, 661.
Gerbillus labradorius, HARLAN, Fn. Amer. 1825, 157 (after Sabine).
GODMAN, Am. Nat. Hist. ii, 1st ed. 1826, p.—; 2d ed. 1831, 97; 3d ed. 1861, 97.
GRIFFITH, Anim. Kingd. v, 1827, 240, No. 625.
Dipus labradoricus, FISCHER, Syn. Mamm. 1829, 338.
Meriones labradorius, RICHARDSON, F. B.-A. i, 1829, 144, pl. 7.
WAGNER, Suppl. Schreb. iv, —, pl. 226 B (after Richardson).
DAWSON, Edinb. N. Philos. Journ. 1856, 2.
Meriones labradorus, SCHINZ, Syn. Mamm. ii, 1845, 92.
Jaculus labradorius, WAGNER, Suppl. Schreb. iii, 1843, 294.
GIEBEL, Säug. 1855, 599; Zeitschr. gesammt. Naturw. xxv, 1865, 272 (osteology).
KENNICOTT, U. S. Patent-Office Agric. Rep. for 1856, 1857, 95, pl. 11 (habits).
MAXIMILIAN, Arch. Naturg. 1861, p. —; Verz. Reise N.-Am. 1862, 146.
Gerbillus sylvaticus, "MITCHILL." descr. nulla.
Meriones nemoralis, IS. GEOFFROY, "Dict. Class. vii, 323; pl. fasc. 10, n. 2."
Gerbillus daviesii, RAFINESQUE, "Préc. Découv. Sémiol. 14."
Gerbillus soricinus, RAFINESQUE, "Préc. Découv. Sémiol. 14."
DESMAREST, Mamm. ii, 1822, 322 (compiled from Rafinesque).
LESSON, Man. i, 1827, 257 (compiled from Rafinesque).
Dipus soricinus, FISCHER, Syn. Mamm. 1829, 339 (compiled from Rafinesque).

? Gerbillus leonurus, RAFINESQUE, Am. Month. Mag. 1818, 446.
DESMAREST, Mamm. ii, 1822, 322 (compiled from Rafinesque).
LESSON, Man. i, 1827, 257 (compiled from Rafinesque).
? Dipus leonurus, FISCHER, Syn. 1829, 339 (compiled from Rafinesque).
? Gerbillus megalops, RAFINESQUE, Am. Month. Mag. 1818, 446.
DESMAREST, Mamm. ii, 1822, 322 (compiled from Rafinesque).
LESSON, Man. i, 1827, 257 (compiled from Rafinesque).
? Dipus megalops, FISCHER, Syn. 1829, 340 (compiled from Rafinesque).
? Gerbillus macrourus, RAFINESQUE.
? Gerbillus brachyurus, RAFINESQUE.
Meriones microcephalus, HARLAN, Proc. Zool. Soc. Lond. vii, 1839, 1.
SCHINZ, Syn. Mamm. ii, 1845, 92 (compiled from Harlan).
Meriones acadicus, DAWSON, Edinb. N. Philos. Journ. iii, 1856, 2, pl. 1.
Canada Rat, PENNANT, Quad. ii, , 172.
Labrador Rat, PENNANT, Hist. Quad. 1781, 435, No. 295; Arct. Zool. i, 1784, 132, No. 63.
Jumping Mouse of Canada, DAVIES, *l. c.*
Labrador or Jumping Mouse, GODMAN, *l. c.*
Canadian Jerboa, SHAW, *l. c.*
Labradore Jerboa, TURTON, *l. c.*
Canadian and Labrador Gerbil, GRIFFITH, *l. c.*
Deer Mouse, DEKAY, *l. c.*
Gerbille du Canada, DESMAREST, *l. c.*
Mérione du Canada, LESSON, *l. c.*
Gerbille soricine, de la baie d'Hudson, queue de lion, et aux yeux noirs, LESS., *l. c.*
Canadische, Labradorische, Kleinköpfige Hüpfmaus, SCHINZ, *l. c.*

Description.

Cranial and dental characters.—In comparison with the murine forms with which it has been associated, this animal presents many strong peculiarities of the skull and teeth. Among these may be enumerated the presence of an additional tooth in the upper molar series, causing an inequality in the formulæ of the two jaws; the size and shape of the anteorbital foramen, with its supplementary foramen or nick just beneath; the extension of the malar bone up the slender styloid zygomatic portion of the maxillary till it sutures with the lachrymal, and the slenderness and depression of the rest of the zygomatic arch; the shortness and transverse position of the bullæ auditoriæ; the position of the maxillo-palatine suture; expansion of the posterior nares, &c. The skull, as a whole, is shorter for its width, though the zygomata are even more nearly parallel; it is also deeper for its other dimensions, with a greater degree of convexity, both lengthwise and crosswise, of the superior contour. Nevertheless, its general superficial resemblance, aside from details, to that of *Mus* proper, is evident. Compared with that of *Mus musculus*, which is of about the same size, we see in each species the same general shape and delicate papery condition, without strong angularity, as well as many close coincidences in detail, indicating that the murine affinities of the family are with typical *Mus*, *Hesperomys*, &c., and not with the arvicoline group of *Muridæ*, in which the skull is notably heavier, more massive, and angular.

As to the general shape of the skull, there is little to be added to the foregoing, except such points as, being equally applicable to the familiar *Mus musculus*, need not be recapitulated; we may therefore at once proceed to details.

The anteorbital foramen, which transmits the masseter in this instance, and which constitutes a prime peculiarity of the skull, is of great size and obliquely oval in shape. Instead of being circumscribed by a plate of bone, as in *Muridæ*, it is defined externally by a very slender styloid process of the maxillary, which is strengthened by the upward extension of the malar, applied as a splint along its whole length. Below this main foramen there is another much smaller one, which transmits the

nerve. It is sometimes a complete foramen, separate from the other; sometimes only a deep notch in the lower border of the main opening; and this difference may be observed on the two sides of the same skull. I am ready to believe that this lesser opening, giving passage to the superior maxillary nerve, is the true "anteorbital" foramen itself; for it seems to correspond to the lower part of the large slit in *Muridæ*, which is walled in by the maxillary lamina, and it is formed by a little plate of bone, which rises as a ridge from the alveolar portion of the jaw, and bends over to abut against the main wall of the maxillary. In cases in which this plate fails to reach the main wall of the maxillary, so that only a notch and not a foramen results, the correspondence of the whole opening with the pyriform slit of the *Muridæ* is very evident, and the relation of the parts is fully established, though the shape is quite different.

The contour of the parts surrounding the foramen is such, that the zygomatic process of the maxillary stands out from the bone at right angles at a point scarcely above the level of the alveoli. The anterior root of the zygoma is hence notably depressed in position; there being no forward-upward reach of the lower border of this arch, so evident in *Muridæ*. The zygoma, in fact, is nearly horizontal in all of its length along the under side; but anteriorly the upper edge rises prominently, in consequence of the unusual extension of the malar up the maxillary, already mentioned. The malar runs all the way up to the lachrymal bone, affording a circumstance I have not seen elsewhere, and which I believe to be very rare, namely, a lachrymo-malar suture. This ascending spur of the malar is, moreover, expanded into a rather broad lamina, partly defending the orbit, thus supplying a wall that, in most cases, is afforded by expansion of the zygomatic process of the maxillary; the latter being in this case of styloid character. In its continuity, the malar is a slender rod; behind, it underlaps a short spur of the squamosal with simple squamous suture.

The general shape of the orbit is much the same as in *Mus*. In both, the squamosal forms much of the posterior orbital wall; the orbito-sphenoid being correspondingly reduced. The antero-exterior corner of the parietal reaches to the brim of the orbit.

The rostral portion of the skull bears to the rest about the same proportion as in *Mus*, and is equally attenuate anteriorly, though thicker at the base, and consequently more tapering. The ends of the nasals project conspicuously beyond the plane of the incisors; behind, these bones terminate opposite the ends of the intermaxillaries; the suture of the frontal with each of them, as well as with the maxillaries, being nearly in one transverse jagged line. The intermaxillaries develop a strong alveolar plate, separating the superior incisors for nearly half their length; this, with the projection of the nasals and backward set of the much-curved teeth, results in a snout strikingly like that of the *Saccomyidæ*. The feeble retreating under jaw, densely hairy upper lip, and small nasal pads, bear out this resemblance in the external physiognomy.

As in *Mus*, the interorbital constriction is moderate, being about as wide as the rostrum at base; and there is no trace of postorbital processes. The parietals are nearly square, though somewhat emarginate in front, to correspond with the convexity of the frontal. There is little, if any, dipping-down of a postero-exterior angle, so well exhibited in *Mus*. The interparietal is of a large size transversely, though narrow in the other direction; it reaches across the whole width of the combined parietals, bounding them both posteriorly, as it is itself bounded

by the occipital. The extent of this narrowly elliptical transverse interparietal is greater than in *Mus;* its corner is at a point where the back outer angle of the parietal, back upper angle of the squamosal, and front upper angle of the occipital all come nearly together. The squamosal closely resembles that of *Mus* in size, shape, and connections; there are the same extensive vacuities about the petrosal, with a similar strong clasp, bridging over the opening just above the meatus, running from the root of the zygomatic process to the back edge of the bone. The mastoid is of moderate size, developing nothing to be fairly called a process, wedged between the paroccipital process and the squamosal, at the postero-lateral corner of the skull. It is confluent with the petrosal, but partially fissured away from the surrounding occipital elements. The supraoccipital is of large size and convex contour; the occipital crest is slight, so that the plane of the occiput is not well defined from that of the superior surface of the skull, the two meeting with a continuous curve, more convex than in *Mus*. The upper border of the occipital is nearly straight, and bounded quite across by the interparietal; next comes a considerable piece of squamosal suture, and then the mastoid. The foramen is of great size and nearly hexagonal shape; most of it being in the one plane of the occiput, with only a slight nick inferiorly. The condyles are protuberant and convergent; the condyloid foramen is close beneath their articular surfaces. The paroccipital are well-marked vertical processes. The basioccipital narrows very rapidly, owing to the strong inward trend of the petrosals, and ends by transverse suture, as usual, with the basisphenoid, opposite the ends of these bones. Its under surface shows a pair of slight depressions, with a median ridge.

The posterior nares are of ample dimensions, owing to the wide separation of the pterygoids. These bones are long, straight, and styloid, with a slightly-clubbed extremity in close approximation to the ends of the petrosals. The palate ends behind with a broad, rounded emargination opposite the last molars. This formation is very different from that of *Mus*, in which the bony palate extends back of the molar series, and the contracted interpterygoid space is narrowly angular. The maxillopalatine suture of *Zapus*, likewise, is differently located, being opposite the interspace between the penultimate and preceding molar, instead of much farther back. There is a pair of conspicuous palatal foramina opposite the penultimate molar. The contour of the palate differs from that of *Mus*, and perhaps a majority of allied rodents, in being broader in front than behind. The incisive foramina are of great length, as well as quite broad, reaching from little behind the incisors to opposite the molars; the perforation is half in the intermaxillary, half in the maxillary; the bony septum is bullous except at its posterior part.

The form of the descending process of the mandible is a strong character of *Zapus* in comparison with *Mus*, &c., in which this plate of bone is more or less squarish, and vertical or nearly so. In *Zapus*, the same plate is strongly twisted out of the axis of the jaw, standing diagonally outward and upward—very much so, in fact, as witnessed in the *Saccomyidæ*. The coronoid is rather weak, falcate, acute, with a strong slope; it slightly overtops the condyle. The latter sets strongly backward, though it is rather more erect than in *Mus*. The incisor causes a moderate protuberance outside, at the root of the condylar process. Inside, nearly opposite, is the conspicuous foramen of the inferior maxillary nerve.

The superior incisors are short and stout, with a strong curve; their anterior faces strongly sulcate, with the outer half of the tooth rabbeted down so that the groove is plainly visible from the side. The inferior incisors are not specially noteworthy. The molar series differs from

that in *Muridæ* proper in the presence of a small anterior molar (premolar) in the upper jaw, with no tooth to correspond in the lower series. The minute premolar is single-rooted; the three following teeth have three roots apiece—a lengthwise pair of slender fangs outside, and a single stout fang, apparently formed of two coalesced roots, inside. The lower molars have each a pair of roots, in single lengthwise series. The anterior upper molar is the smallest of the whole, and simply circular; the next two are about equal in size; the last is much smaller. A similar proportion is seen in the under series. The pattern of the molar crowns is much complicated.

External characters.—A general murine form is modified by the great development of the hind limbs (much as in *Dipodidæ* or some forms of *Saccomyidæ*), and especially of the pes itself; an unusual length of tail, which greatly exceeds that of the body; a peculiar condition of the external ear; and a physiognomy quite like that of the *Saccomyidæ*. There are also well-developed internal cheek-pouches, shared in a less degree, however, by various American *Muridæ*.* These pouches, as well as can be judged from alcoholic specimens, are relatively about as large as those of *Tamias* for instance.

The body of *Zapus* is large behind, in correlation with the greatly-developed posterior limbs, and tapers to the fore in a regular manner; the head being comparatively small, and there being no noticeable constriction of the neck. The head is conoidal, with a prominent and rather blunt snout and retreating under jaw. The rather small eye is midway between the nose and ear. The upper lip is not visibly cleft, and is densely hirsute, with a fringe of hairs depending over and almost hiding the small front teeth. The naked muffle is of rather small size, and entirely inferior in position; above it, the hairy skin crosses with a deep transverse crease, forming a sort of imperfect overhanging flap, which is freely movable back and forth, even in alcoholic specimens, and looks as if it might be drawn down to partially cover the nostrils. (I have observed much the same thing in *Saccomyidæ*.) The nose-pad is impressed with a pair of median vertical grooves, and a transverse one is seen in some cases. The nostrils are completely lateral in position. The whiskers are rather sparse, but some of them are nearly half as long as the body.

The structure of the external ear is rather remarkable (among rodents) for the provision for perfect closure of the meatus, as in the *Soricidæ* for instance. The antitragus develops into a great flap, completely reversible, and capable of being applied against the meatus; and such, in fact, appears to be its usual position. The tragus, likewise, expands into a wide frill, or thin, free, rounded border, which ordinarily lies in apposition to the antitragal lobe opposite, completing the closure of the ear. On turning over these two flaps, the vestibule of the ear is seen to be of unusually large dimensions. The conch itself is of an ordinary contour, coming to a blunt point above; the anterior third is folded close back. The back of the ear and the fold of the conch are sparsely pilous; the

*The presence of cheek-pouches in the genus *Hesperomys* was first noted in 1830 by Gapper, who referred specimens of the common *Hesperomys leucopus* to *Cricetus* on this account, establishing a species *C. myoides*. In this matter, he was succeeded by Baird in 1857, who also recognized the pouches, and endorsed a *Hesperomys myoides* mainly upon this feature, failing, however, to observe that they also existed in other species of the same genus. At the same time that Mr. J. A. Allen announced the before unknown pouches of *Zapus hudsonius*, he also showed that they occurred as well in various species of *Hesperomys*; and my subsequent dissections have satisfied me that pouches are present in all the North American species of *Hesperomys* proper; *i. e.*, the subgenus *Vesperimus* as established by me; Proc. Acad. Nat. Sci. Phila., 1874, 178.

exposed parts of the front of the ear being more thickly clothed. The antitragal pad bears on its outer surface a special tuft of long hairs; its other side being naked, as are both sides of the flap of the tragus.

The fore limbs are absolutely small as well as short relatively to the hinder ones; and they seem to be placed rather far forward, though this appearance may be due, in part at least, to the tapering shape of the body. The hands are pilous above, naked below. There are four perfect fingers, with ordinary claws, and a rudimentary thumb, which bears a flat, blunt nail. The third digit is the longest; the fourth, second, and fifth being successively shortened. The digits are regularly transversely scutellate below. The palm is granular throughout, with a pair of large smooth pads (inner and outer) near the wrist, and three smaller tubercles at the base of, respectively, the second, the fifth, and the conjoined third and fourth digits.

The elongation of the hind limbs, which confers the high degree of saltatorial power upon this animal, like that of *Dipus*, &c., to which it has been referred, is especially noticeable in the pes, which exceeds the crus in length. This development of the foot, nevertheless, is not accompanied by reduction of the digits in number, nor by any imperfection of their respective metatarsals. The number of these bones has been queried; I find five, perfect from end to end, with complete tarsal and phalangeal articulations. The foot is clothed above with short, soft, silky hairs, quite different from the hirsute pelage of the body; below it is entirely naked, though the lateral fringe of hairs encroaches upon the contracted heel. The sole is perfectly smooth (as in *Mus*) for about half-way, then granular; the digits are transversely scutellate underneath. There is a well-defined tubercle on the inner side a little distance above the base of the first digit, and four others at the bases of, respectively, the first, second, fifth, and conjointed third and fourth digits. There are five perfect and normally-clawed digits. The first is shortest, and also situated rather high up, so that its tip reaches only to about the base of the second. The fifth is next longer, reaching the middle of the fourth. The third slightly exceeds the fourth and second, which are about equal to each other. There is much basal webbing between the three intermediate digits—especially between the third and fourth—which carries their apparent bases far beyond the bases of the lateral digits.

In its relative length, the tail exceeds that of any other North American (mammal?) rodent, always greatly exceeding the head and body, and sometimes measuring nearly twice as much. It is cylindrical, with uniform taper and very slight caliber, coming to a fine point with a slight pencil of hairs. Its hairiness is about on a par with that of *Mus musculus*, *decumanus*, &c.; that is to say, insufficient to hide the verticillate whorls of scales between which the short hairs spring.

The general pelage of this animal is coarse and hispid, with little gloss, and presenting a streaky or "staring" appearance, owing to the number of bristly hairs which are mixed with the softer under fur. The color varies a good deal in different specimens, though one pattern is pretty constantly preserved. About one-third of the colored part of the fur—that is to say, a dorsal strip about as wide as the lateral strip on either side—is brownish-yellow, heavily shaded with brownish-black. The sides, with the outer surface of the limbs, are of this same sandy-yellowish, but so slightly lined with the blackish that the purity of the light color is scarcely interfered with. The under parts are snow-white, with a pretty sharp line of demarcation from the colored areas. The backs of the hands and feet are whitish. The tail is rather indistinctly

bicolor, to correspond with the body-areas—dark-brown above, whitish below. The ears have a light-colored rim. The whiskers are mostly black. The basal part of the fur, in the colored areas, is gray or plumbeous, excepting just along the line of junction of the tawny of the sides with the white of the belly, where the hairs are white to the roots, like those of the belly. To this absence of dark bases of the hairs is due the appearance of a fulvous stripe along the sides, sometimes quite strongly marked, much as in species of *Perognathus* or *Cricetodipus*. In these cases there are thus four styles of coloration from back to belly: the dark dorsal area, mixed blackish and sandy, with plumbeous roots; sandy, with little or no blackish, but still with gray roots; sandy, with white roots; and finally pure white. The variations to which the species is subject lie in the brightness or dullness of the tawny, and its lining with a varying amount of blackish; the degree of distinctness of the dorsal area from that of the sides, and of this from the white of the belly; and in the sharpness or indistinctness of the tawny lateral stripe along which the hairs are white at the roots. The line of the belly-white is pretty constantly sharp, as in *Hesperomys;* but there is often a very gradual shading from the dark dorsal area to the tawny of the sides, and the latter is sometimes very pale yellowish-gray, &c. I have observed no plumbeous or entirely gray stage like that of young *Hesperomys* in general; and I have failed to determine what definite relation, if any, the observable differences in coloration bear to sex or age.

The animal varies much in size, and to some extent in proportions, especially the length of the tail. This is the most variable dimension, as usual in all such cases of high development of parts. A tendency to superior size in specimens from the Rocky Mountains and westward has been noted. The following table of measurements of an alcoholic series indicates very fairly the dimensions, and, to some extent, the variations, in size and proportions:

Measurements of twenty-one alcoholic specimens (English inch and decimals).

National Museum No.	Locality.	From tip of nose to—				Tail—	Length of—	
		Eye.	Ear.	Occiput.	Tail.	Vertebræ.	Fore foot.	Hind foot.
2592	Halifax, N. S	0.45	0.80	1.00	2.75	5.00	0.40	1.20
2393	Middleboro', Mass	0.42	0.75	1.00	2.90	5.25	0.35	1.18
2395	do	0.45	0.90	1.00	3.00	5.00	0.37	1.20
2396	do	0.42	0.80	0.95	2.75	4.50	0.45	1.12
2397	do	0.40	0.80	0.95	3.00	5.30	.....	.....
2398	do	0.43	0.85	1.00	2.75	4.75	0.35	1.15
2594	Burlington, Vt	0.45	0.90	1.00	3.30	5.35	0.40	1.18
2599	Wethersfield, Conn	0.45	0.90	1.00	2.75	4.80	0.40	1.10
2600	do	0.45	0.80	1.00	2.75	4.35	0.35	1.15
2605	Waterville, N. Y	0.45	0.90	1.10	3.10	4.95	0.45	1.15
2606	do	0.50	0.95	1.00	3.25	5.00	.....	.....
2607	do	0.45	0.85	1.00	2.85	4.90	0.40	1.15
2608	do	0.45	0.90	1.00	3.00	5.00	0.40	1.15
2604	Philadelphia, Pa	0.45	0.85	1.00	2.90	4.65	0.45	1.13
2601	Carlisle, Pa	0.45	0.85	1.00	2.85	4.50	0.45	1.15
2602	do	0.45	0.85	1.00	2.85	4.75	0.45	1.15
2603	do	0.40	0.80	0.95	2.60	4.40	0.40	1.05
2611	West Northfield, Ill	0.40	0.80	0.90	2.80	4.70	0.40	1.10
2610	Upper Missouri	0.50	1.00	1.15	3.00	5.10	0.48	1.15
1929	Platte River, Nebr	0.40	0.80	0.95	2.75	4.50	0.45	1.12
2609	Steilacoom, W. T	0.45	1.00	.....	.....	6.10	0.50	1.35
	Average	0.44	0.86	0.99	2.89	4 90	0.42	1.15

Skulls measure from 0.90 to 1.00 by 0.45 to 0.50.

Geographical Distribution.

The dispersion of *Zapus hudsonius* in North America can at present be given only in somewhat general terms, pending precise information respecting both northern and southern limits of its distribution. It inhabits the greater part of British America and the United States, from ocean to ocean. The northernmost recorded locality we have noted is Great Slave Lake, latitude 62°; and the southernmost is Virginia, where we have ourselves observed it. It was originally described from Hudson's Bay, Labrador, and Canada, and appears to be particularly numerous in the last-named region and northern half of the United States. Audubon surmises, with much reason, that it exists south of Virginia, at least in mountainous regions; while there is no doubt of its presence in elevated portions of Arizona and New Mexico, which harbor such a truly boreal animal as *Gulo luscus*. We have found it in Dakota, and it is known to exist on the Pacific coast, in Washington Territory; while the moist and comparatively warm climate of the wooded region, thence northward, we may properly surmise, will carry its habitat far into Alaska. Its dispersion will probably ultimately prove to be little, if any, less extensive than that of *Hesperomys leucopus*; although, as it is more strictly a woodland animal, there are large treeless areas within its general range where probably it does not occur.

History.

The latter part of the last century gave us our early accounts of this animal under four different names, from three distinct sources—Pennant, Davies, and Barton. Thomas Pennant appears to have first described it under the name of the "Long-legged Mouse of Hudson's Bay", whence comes the first technical appellation *Dipus hudsonius*, conferred by Zimmermann in 1780. Pennant also had a "Labrador Rat", the description of which applies perfectly to the present species; and, furthermore, a "Canada Jerboid Rat", failing to recognize the fact that all three were the same. Pennant further erred in hastily identifying the animal sent from Hudson's Bay by Mr. Graham with the *Mus longipes* of Pallas, or *Dipus meridianus* of Gmelin, an Asiatic quadruped. Pennant's three animals became the bases of as many technical names—*hudsonius*, *labradorius*, and *canadensis*—the last of these at the hands of General Davies, who, in 1797 or 1798, communicated to the Linnæan Society "an account of the Jumping Mouse of Canada (*Dipus canadensis*)", which was published in the Transactions of that body for 1798, as above cited, accompanied by figures. General Davies gave a fair account of the animal, which was copied into Dr. G. Shaw's General Zoology, with the figures representing the creature in activity and repose. These cuts, though now seeming very rude, are quite characteristic and unmistakable. Joseph Sabine is currently accredited with the authorship of the term *Mus labradorius*, based upon Pennant's Labrador Rat; but a *Dipus labradorius* had already appeared in 1806 in Turton's English version, with compiled additions, of the Linn.-Gmelinian Systema Naturæ. Meanwhile, the third independent source of information, following Pennant and Davies, had appeared in 1799, when Prof. Benjamin S. Barton gave "some account of an American species of Dipus or Jerboa", and named the animal *Dipus americanus* in the Transactions of the American Philosophical Society, as above cited. This seems to have been the earliest reference to the animal as an inhabitant of the United States; and the name was given in ignorance of the earlier accounts from British

America. Such, however, was not the case with the two later synonyms we have adduced. After treating of "*Gerbillus labradorius*" from fair acquaintance in 1825, Dr. Harlan, in 1839, described specimens from Philadelphia as a new species, under the designation of *Meriones microcephalus;* while, still later, Nova Scotian examples received from Principal Dawson the appellation of *Meriones acadicus*. But the characters adduced by both of these authors fail to indicate anything tangible; and it is certain that if more than one species of *Zapus* inhabits North America, it remains to be discovered; for the several queer animals of this kind indicated about the year 1817 by M. Rafinesque, under the names of Short-tailed, Long-tailed, Lion-tailed, Shrew-like, and Big-eyed, are undoubtedly figments of that author's fertile imagination. We quote these names with a query, together with the compiled accounts that go with them, merely observing that, if they do not belong to *Zapus hudsonius*, they certainly belong nowhere else. To give credit where it is due, however, we should not omit to add that, besides these five "new species" of "Gerbillus", M. Rafinesque furnishes us with two others—*G. daviesii*, which is merely another name for Davies's *Dipus canadensis*, and *G. hudsonius*, in presenting which last he has the credit of leading the adoption of the specific name which has priority, and which must unquestionably be adopted. Recurring once again for a moment to the earlier dates in the history of the species, we find a name *Gerbillus sylvaticus*, imposed by Mitchill, but without an accompanying description; and still another, said to have been given by Isidore Geoffroy in the seventh volume of the Dictionnaire Classique—*Meriones nemoralis*.

It would appear, from the foregoing sketch of its history, that this animal was already quite sufficiently named; but this is only a consideration of its specific appellations, without reference to the various generic terms by which it has been designated by authors, nearly all of whom seem determined to make it out to be some kind of a Jerboa, because of its powers of leaping. But nothing is more certain than that it is not generically related to any of the *Dipodidæ*. It has usually been placed at least in a subfamily *Dipodinæ*. The family value of its characters were only lately recognized, when, in 1872, Dr. Gill constituted a family *Jaculidæ*, overlooking the fact, as Professor Baird had also done, that the name *Jaculus* was pre-occupied in another connection.

B. B. R. A. S.

Not to be kept more than days.

XX.	Coues (Dr. E.)—Some Account of Zapus Hudsonius, and on the Breeding-Habits, Nest, &c. of Lagopus Leucurus Washington, 1875	1	Pht.

First issued on the *Vol.*

Names of Applicants.	Issued.	Returned.

551.9
Hun/Ont
551.9
Hun

ON THE CHEMISTRY OF THE EARTH.

By T. Sterry Hunt, LL. D., F. R. S.

In the following pages I have endeavored, at the request of Professor Henry, to give a brief summary of certain views in chemical geology which have been put forward by me in various scientific journals during the past twelve years, the germ of them having appeared in a communication to the *American Journal of Science* in January, 1858. In addition to the foot-notes, I have appended a list of my principal publications on the subject, where those who desire to follow up the various questions here suggested will find them treated more at length. The last three of these papers are in part reprinted in the present abstract. I take this occasion to say that the views here embodied will be developed in a work on the chemistry of the globe, the preparation of which is now well advanced.

T. STERRY HUNT.

Montreal, *January* 6, 1870.

List of the principal papers, by Mr. T. Sterry Hunt, relating to Chemical Geology.

On the Chemistry of the Primeval Earth. American Journal of Science, January, 1858.

On the part which the Silicates of the Alkalies may play in the Metamorphism of Rocks. Proc. Royal Society of London, May 7, 1857, and American Journal of Science, March, 1858.

On the origin of Feldspars, and on some points of Chemical Lithology. American Journal of Science, May, 1858.

On the Theory of Igneous Rocks and Volcanoes. Canadian Journal of Toronto, March, 1858.

On some points in Chemical Geology. Quarterly Journal of the Geological Society, November, 1859.

Review of the last-named paper. American Journal of Science, July, 1860.

On Gypsums and Magnesian Rocks. American Journal of Science, September, November, 1859.

On the History of Lime and Magnesia Salts. American Journal of Science, July, 1866.

Contributions to Lithology. American Journal of Science, March, May, July, 1864.

Chemistry of Natural Waters. American Journal of Science, March, July, September, 1865.

Chemistry and Mineralogy of Metamorphic Rocks. Dublin Quarterly Journal, July, 1863.

Origin of some Magnesian and Aluminous Rocks. American Journal of Science, September, 1861.

La Chimie de la Terre. Comptes-Rendus de l'Académie, June 9, 1862.

The Earth's Climate in Paleozoic Times. American Journal of Science, 1863.

On some points in American Geology. American Journal of Science, May, 1861.

On the Chemical Geology of Mr. David Forbes. Geological Magazine, February, 1868.

On the Chemical Geology of Mr. David Forbes. Chemical News, February, 1868.

The Chemistry of the Primeval Earth. Lecture before the Royal Institution, May, 1867.

Volcanoes and Earthquakes. Lecture before the American Geographical Society, April, 1869.

On the Probable Seat of Volcanic Action. Geological Magazine, June, 1869.

CONTENTS OF SECTIONS.

1–3, classification of the sciences; 4, objects of chemical geology; 5, nebular hypothesis; 6, dissociation; 7, 8, the sun; 9, the cooling earth; 10–13, its solidification; 14, relations of solution to pressure; 15, on the earth's crust; 16, 17, probable composition and relation of earth's crust and atmosphere; 18, fixation of carbonic acid, its effect on climate; 19, chemical influence of vegetation as a reducing agent; origin of carbon and sulphurets; 20, origin of limestones, dolomites, and gypsums; 21, silicated waters; 22, relations of potash and soda; 23–26, disintegration of silicated rocks; 27, their division into two groups; 28, chemically-formed aluminous and non-aluminous silicated rocks; 29, changes in composition of sediments; 30, 31, metamorphism of rocks; 32, chemical alteration; 33, molecular alteration; 34, porosity of sediments, their condensation; 35, ultimate result of chemical metamorphism; 36, theory of volcanic action; 37, views of Keferstein and Herschel; 38, the primitive crust; 39, internal heat; 40, 41, influence of pressure; 42, 43, types of igneous rocks; 44, origin of granites; 45, indigenous and exotic rocks; endogenous rocks or vein-stones; 46, filling of mineral veins; 47, source of metals, and theory of metalliferous deposits; 48, earthquakes; 49, volcanoes; 50, 51, their distribution; 52, causes of subsidence and accumulation of sediments; theory of mountains; 53, origin of lavas; 54, relations of sedimentary deposition to volcanic phenomena; ancient volcanoes; 55, modern volcanoes.

---

§ 1. In approaching the study of the chemistry of the earth, or what may be designated chemical geology, it becomes necessary to define the natural objects of that complex study to which is given the general name of geology, and also to consider its connection with the various sciences. To this end, some notions as to the order and the relation of these sciences may not be out of place. Following the classification established by Comte, we distinguish between the abstract sciences, which deal with laws, and the concrete sciences, which have to do with things. In their order the abstract sciences form an ascending series, according to the degree of complexity of their phenomena, "so that each science depends on the truths of all those which precede it, with the addition of peculiar truths of its own."—(J. S. Mill.) At the base of this series are thus placed—1st, *Mathematics*, with its successive divisions of number, geometry and mechanics; 2d, *Abstract Astronomy*, which considers, in addition to these, gravitation, taking cognizance of number, extension, equilibrium, and motion; 3d, *Physics*, comprehending the laws of weight, cohesion, sound, light, electricity, and magnetism; 4th, *Chemistry*, which treats of the relations to one another of the different forms of mineral matter, and their transformations under the physical agencies of light, heat, and electricity; 5th, *Biology*, or *Physiology*, to which belongs the study of the laws of organized growth and development; 6th, *Psychology*, which considers the laws of mental phenomena; and, 7th, *Sociology*, or the laws of human society.

§ 2. Parallel with these abstract sciences is a series of concrete or historical sciences, dealing not with laws and general principles, but with objects and facts. Of these concrete sciences the first is *Descriptive Astronomy*, which is the natural history of the planetary and stellar worlds, treating of their movements, dimensions, and cosmical relations. Coming, in the next place, to the history of our own planet, the study of the accidents of its surface and its interior gives rise to *Physical Geography* and to *Structural* and *Dynamical Geognosy*; while the bodies which it presents to us are naturally divided into two great classes, the inorganic or mineral kingdom, and the organic, including the vegetable and animal kingdom. The study of these two classes gives rise to two great branches of natural history, *Mineralogy* and *Organography*, the latter including *Botany* and *Zoology*. The concrete science of mineralogy has for its subject the natural history of all the forms of unorganized mat-

ter; that is to say, those substances which are exempt from biological laws, but come within the domain of physics and chemistry. Chemical change implies disorganization, and all so-called chemical species are inorganic, that is to say, unorganized, and belong to the mineral kingdom, whose natural history is thus physical and chemical, while that of the vegetable and animal kingdoms is biological.*

§ 3. It might, at first sight, seem foreign to our present subject to speak in this connection of the moral, social, and political history of mankind, dependent upon the laws of psychology and sociology. It is, however, to be remarked, that while in the abstract order each science is independent of that which follows it in the series, it is far different in the concrete sciences. This is seen in the familiar example of the dependence upon each other of the animal, vegetable, and mineral kingdoms, and it is evident that man puts in movement agencies which are constantly at work modifying alike physical geography and the relations of the mineral, vegetable, and animal world to such an extent that human history must not be disregarded in the study of the lower reigns of nature.

§ 4. From what has gone before it will be evident that under the common term of geology are generally confounded two distinct branches of study; the first or abstract division being that of the physical, chemical, and biological laws which have presided over the development of the globe, and the second or concrete division, the natural history of the earth as displayed in its physical structure, stratigraphy, mineralogy, paleontology. The name of geognosy, employed by some authors, may very appropriately be retained for the latter, while that of geology is restricted to the former division. It is proposed in the following pages to consider briefly some of the more important points in the chemical history of the globe; in doing which it will be necessary to notice also its astronomical and physical history, and the relations of organic life, in so far as they are concerned in the chemical history of the earth in its various stages of development. The scheme thus embraced is so great that in the limits of the present essay nothing more can be attempted than a sketch which shall embrace some of the most striking facts in the history of the forming globe considered as a condensing nebulous mass, in the chemistry of the air, sea, and earth in past ages, and in the relations of the central heat to the superficial portions of the earth, by which we shall endeavor to explain certain facts in dynamical geology, such as the great movements of the earth's crust and the phenomena of earthquakes and volcanoes.

§ 5. The nebular hypothesis, as it is called, which supposes that our solar system and all the worlds of space have come from the condensation of diffused vapors, has received strong confirmation from the discoveries made by the spectroscope. We now know that there exist in the heavens nebulæ consisting of luminous gas; that is to say, vaporous matter shining by its own light, which we may, with great probability, regard as the primal matter out of which, as the elder Herschel suggested, suns and planets have been formed by a process of condensation. By the aid of the telescope and the spectroscope we find in the heavens, planets—bodies like our earth, shining only by reflected light; suns,—self-luminous, radiating light from solid matter; and, moreover, true nebulæ, or masses of luminous vapor. These three forms represent three distinct phases in the condensation of the primeval matter, from which our own and other planetary systems have been formed.

* T. S. Hunt, on the Objects and Method of Mineralogy. American Journal of Science, [2,] xliii; 203.

This nebulous matter is conceived to be so intensely heated as to be in the state of true gas or vapor, and, for this reason, feebly luminous when compared with the sun. It would here be out of place to discuss the detailed results of spectroscopic investigation, or the beautiful and ingenious methods by which modern science has shown the existence in the sun, and in many other luminous bodies in space, of the same chemical elements that are met with in our earth.

§ 6. Calculations based on the amount of light and heat radiated from the sun show that the temperature which reigns at its surface is so great that we can hardly form an adequate idea of it. Of the chemical relations of such intensely heated matter modern chemistry has made known to us some curious facts, which help to throw light on the constitution and luminosity of the sun. Heat, under ordinary conditions, is favorable to chemical combination, but a higher temperature reverses all affinities. Thus, the so-called noble metals, gold, silver, mercury, &c., unite with oxygen and other elements; but these compounds are decomposed by heat, and the pure metals are regenerated. A similar reaction was many years since shown by Mr. Grove with regard to water, whose elements—oxygen and hydrogen—when mingled and kindled by flame, or by the electric spark, unite to form water, which, however, at a much higher temperature, is again resolved into its component gases. Hence, if we had these two gases existing in admixture at a very high temperature, cold would actually effect their combination precisely as heat would do if the mixed gases were at the ordinary temperature, and literally it would be found that "frost performs the effect of fire." The recent researches of Henry Sainte-Claire Deville and others go far to show that this breaking-up of compounds, or dissociation of elements by intense heat is a principle of universal application; so that we may suppose that all the elements which make up the sun or our planet would, when so intensely heated as to be in that gaseous condition which all matter is capable of assuming, remain uncombined, that is to say, would exist together in the condition of what we call chemical elements, whose further dissociation in stellar or nebulous masses may even give us evidence of matter still more elemental than that revealed by the experiments of the laboratory, where we can only conjecture the compound nature of many of the so-called elementary substances.

§ 7. The sun, then, is to be conceived of as an immense mass of intensely heated gaseous and dissociated matter, so condensed, however, that notwithstanding its excessive temperature, it has a specific gravity not much below that of water; probably offering a condition analogous to that which Cagniard de la Tour observed for volatile bodies when submitted to great pressure at temperatures much above their boiling point. The radiation of heat going on from the surface of such an intensely heated mass of uncombined gases will produce a superficial cooling, which will permit the combination of certain elements, and the production of solid or liquid particles; these, suspended in the still dissociated vapors, become intensely luminous, and form the solar photosphere. The condensed particles, carried down into the intensely heated mass, again meet with a heat of dissociation, so that the process of combination at the surface is incessantly renewed, while the heat of the sun may be supposed to be maintained by the slow condensation of its mass; a diminution by $\frac{1}{1000}$th of its present diameter being sufficient, according to Helmholtz, to maintain the present supply of heat for twenty-one thousand years.

§ 8. This hypothesis of the nature of the sun and of the luminous process going on at its surface is the one lately put forward by Faye,

and, although it has met with opposition, appears to be that which accords best with our present knowledge of the chemical and physical conditions of matter, such as we must suppose it to exist in the condensing gaseous mass which, according to the nebular hypothesis, should form the center of our solar system. Taking this, as we have already done, for granted, it matters little whether we imagine the different planets to have been successively detached as rings during the rotation of the primal mass, as is generally conceived, or whether we admit with Chacornac a process of aggregation or concretion operating within the primal nebular mass, resulting in the production of sun and planets. In either case we come to the conclusion that our earth must at one time have been in an intensely heated gaseous condition such as the sun now presents, self-luminous, and with a process of condensation going on at first at the surface only, until by cooling it must have reached the point where the gaseous center was exchanged for one of combined and liquefied matter.

§ 9. Here commences the chemistry of the earth, to the discussion of which the foregoing considerations have been only preliminary. So long as the gaseous condition of the earth lasted, we may suppose the whole mass to have been homogeneous; but when the temperature became so reduced that the existence of chemical compounds at the center became possible, those which were most stable at the elevated temperature then prevailing, would be first formed. Thus, for example, while compounds of oxygen with mercury, or even with hydrogen, could not exist, oxides of silicon, aluminium, calcium, magnesium, and iron might be formed and condensed in a liquid form at the center of the globe. By progressive cooling, still other elements would be removed from the gaseous mass, which would form the atmosphere of the non-gaseous nucleus. We may suppose an arrangement of the condensed matters at the center according to their respective specific gravities, and thus the fact that the density of the earth as a whole is about twice the mean density of the matters which form its solid surface may be explained. Metallic or metalloidal compounds of elements, grouped differently from any compounds known to us, and far more dense, may exist in the center of the earth. The condensing effect of pressure as we approach the center of the globe has, however, been regarded by some as far more than sufficient to account for the considerable mean density of the planet, and, according to Dr. Young, would be sufficient to reduce a mass of granite, transported to the earth's center, to one-eighth of the bulk which it occupied at the surface, which would give to the earth a mean density equal to twelve or thirteen times that of water. This consideration has led a recent writer to conclude, with Herbert Spencer, that our earth and the other planets may be only shells of varying thickness, inclosing a central cavity filled with vaporous matter, by which hypothesis may be explained their apparently feeble density. It is, however, a matter of indifference, so far as our argument is concerned, whether the process of condensation commenced around such a central cavity, or at the center of the globe itself.

§ 10. The processes of combination and cooling having gone on until those elements which are not volatile in the heat of our ordinary furnaces were condensed into a liquid form, we may here inquire what would be the result, upon the mass, of a further reduction of temperature. It is generally assumed that in the cooling of a liquid globe of mineral matter, congelation would commence at the surface, as in the case of water; but water offers an exception to most other liquids, in-

asmuch as it is denser in the liquid than in the solid form. Hence, ice floats on water, and freezing water becomes covered with a layer of ice, which protects the liquid below. Some metals and alloys resemble water in this respect. With regard to most other substances, and notably the various minerals and earthy compounds like those which may be supposed to have made up the mass of the molten globe, the case is entirely different. The numerous and detailed experiments of Charles Deville, and those of Delesse, besides the earlier ones of Bischof, unite in showing that the density of fused rocks is much less than that of the crystalline products resulting from their slow cooling, these being, according to Deville, from one-seventh to one-sixteenth heavier than the fused mass, so that if formed at its surface they would, in obedience to the laws of gravity, tend to sink as soon as formed.

§ 11. The stony materials of the earth's crust then, unlike ice and certain metals, expand in melting and contract in passing into the solid state. The melting of ice is a process of condensation, and hence pressure favors its liquefaction, causing it to melt at a lower temperature than it would otherwise do; but for bodies with which melting is a process of expansion, pressure produces an opposite effect, namely, that of augmenting the fusing point. These conclusions of James Thompson and William Thompson have been experimentally verified by Bunsen, Fairbairn, and Hopkins. It results from this physical law that the effect of pressure upon materials like molten rocks would be such that solidification at a depth from the surface would take place at a temperature much higher than that required for their solidification at the surface. Hence, in opposition to the notion of a congealed layer, like a sheet of ice, resting upon the surface of a molten globe, Hopkins, and with him Scrope, supposes solidification to have commenced at the center of the liquid mass and to have advanced toward the circumference. Mr. Hopkins concludes that the pressure existing at great depths must have induced congelation of the molten mass at temperatures at which, under a less pressure, it would have remained liquid. Before the last portions became solidified, there was produced, it is conceived by Mr. Hopkins, a condition of imperfect liquidity, preventing the sinking of the cooled and heavier particles, and giving rise to a superficial crust, from which solidification would proceed downward. There would thus be inclosed between the inner and outer solid parts, a portion of uncongealed matter, which, according to him, may be supposed still to retain its liquid condition, and to be the seat of volcanic action, whether existing in isolated reservoirs or subterranean lakes, or whether, as suggested by Scrope, forming a continuous sheet surrounding the solid nucleus.

§ 12. This view of the constitution of the globe, or one analogous to it, has found favor with many theorists. Professor N. S. Shaler, of Harvard, who, in a recent essay on the formation of mountain chains, in the proceedings of the Boston Society of Natural History, has adopted it, concisely states it as follows: "The earth consists of an immense solid nucleus, a hardened outer crust, and an intermediate region of comparatively slight depth, in an imperfect state of igneous fusion." In this connection it is curious to remark that, as lately pointed out by Mr. J. Clifton Ward, Halley was led, from the study of terrestrial magnetism, to a similar hypothesis. He supposed the existence of two magnetic poles situated in the earth's outer crust, and two others in an interior mass, separated from the solid envelope by a fluid medium, and revolving, by a very small degree, slower than the

outer crust.* The same conclusion was subsequently adopted by Hansteen.

§ 13. Apart from these considerations, however, many of the best modern physicists and geologists have found numerous reasons for rejecting the popular notion which regards our globe as a liquid molten mass covered by a layer of twenty or thirty miles of solidified rock. The deductions of Hopkins from the phenomena of precession and nutation, those of Pratt from the crushing force of immense mountain masses like those of the Himalaya, and those of Sir William Thompson from the tides, showing the great rigidity of the earth, all unite to prove that the earth, if not solid to the center, must have a firm and solid crust several hundred miles in thickness. Under these conditions, if there still exist a liquid center, it must, so far as superficial phenomena are concerned, be as inert as if it were not. We are thus prepared to accept the conclusions to which the line of argument in § 11 leads us, and admit that our globe solidified from the center.

§ 14. It is, then, with the superficial portions of the earth, alone, that we have to do from the moment of its solidification; and as in the subsequent pages of our history air and water must play an important part, it becomes necessary, before going further, to consider briefly the nature of the process of aqueous solution and its relations to pressure. Solution may, for our present purpose, be defined as a chemical union between two or more bodies, of which one is liquid, resulting in a liquid product, and accompanied by a change of volume.† In ordinary cases, as in that of most bodies dissolving in water, this change is in the direction of condensation, and hence, as might be expected, pressure exerts an influence similar to that in the liquefaction of certain bodies by fusion, explained in § 11. Pressure facilitates the liquefaction of ice, which is attended by condensation, and acts in like manner in the case of solution, so that the solubility of salts in water, as shown by the experiments of Sorby, is increased by pressure. We can scarcely doubt that these phenomena of fusion and solution come under one general physical law, and that for all those bodies which contract in dissolving, (to which there are but few exceptions,) their solubility in water must be augmented by and in proportion to the pressure. As expressed by Mr. Sorby, mechanical is thus converted into chemical force.‡

§ 15. Reverting now to the solidified globe, in whose superficial portions and in the surrounding gases and vapors were present all the chemical elements with which we have to do, it is necessary to consider briefly its physical and its chemical condition at this early period.

The formation of a crust at the surface of the viscid layer which still enveloped the solidified mass of the globe, as conceived by Hopkins, is readily admissible; but that this process commenced when the remaining envelope of liquid matter was yet so deep that the refrigeration up to the present time has not been sufficient for its entire solidification is not probable. Such a crust on the cooling superficial layer would, from the contraction consequent on the further refrigeration of the liquid stratum beneath, become more or less depressed, corrugated, and

* The elevated temperature of the interior of the globe would probably offer no obstacle to the development of magnetism. In a recent experiment of M. Trève, communicated by M. Faye to the French Academy of Sciences, it was found that molten cast iron when poured into a mold, surrounded by a helix which was traversed by an electric current, became a strong magnet when liquid at a temperature of 1,300° C., and retained its magnetism while cooling. (*Comptes-Rendus de l'Académie des Sciences*, February, 1869.)

† T. S. Hunt, Thoughts on Solution, American Journal of Science, [2,] xix. 100.

‡ Bakerian Lecture for 1863, L. E. and D. Philosophical Magazine, February, 1864.

broken up, thus causing the extravasation of the yet unsolidified portion, which would contribute to the vast amount of mineral matter brought within the chemical influences of the surrounding atmosphere. Further contraction from cooling would render this material more or less porous and permeable, preparing it for that process of combined mechanical and chemical disintegration which would result from the action of the acid liquids afterwards to be precipitated from the atmosphere.

§ 16. We have next to consider the chemical constitution of this irregular surfaced and broken-up crust of anhydrous and primitive igneous rock, which is now everywhere buried beneath the products of its disintegration. It is evident that, with the exception of those which were still in a gaseous form, it must have contained all the elements which now make up the known rocks of the earth's crust. If we conceive these, together with the air, the ocean, and its dissolved salts, now to react upon each other under the influence of an intense heat, it will enable us to form some notion of the chemical relations of the elements of the globe at the time when they were cooling down from that condition of igneous vapor which we suppose to have been that of our planet at an early stage in its history. To the chemist it is evident that from such a process applied to our globe would result the oxidation of all carbonaceous matter, the conversion of all carbonates, chlorides, and sulphates, into silicates, and the separation of the carbon, chlorine and sulphur in the form of acid gases, which, with nitrogen, watery vapor, and an excess of oxygen, would form an exceedingly dense atmosphere. The resulting fused mass would contain all the bases as silicates, and would probably nearly resemble in composition certain furnace-slags or basic volcanic glasses. Such we may conceive to have been the nature of the primitive igneous rock, and such the composition of the primeval atmosphere, which must have been one of very great density. Under the pressure of a high barometric column condensation would take place at a temperature much above the present boiling point of water, and the lower levels of the half-cooled crust would be drenched with a highly heated solution of hydrochloric acid, whose decomposing action would be powerfully aided by the temperature. The formation of chlorides of the various bases, and the separation of silica, would go on until the affinities of the acid were satisfied, while there would result a sea-water holding in the solution, besides the chlorides of sodium, calcium, and magnesium, salts of aluminum and other metallic bases. At a later period the gradual combination of oxygen with sulphurous acid would eliminate this from the atmosphere in the form of sulphuric acid. The atmosphere being thus deprived of its volatile compounds of chlorine and sulphur, would approach to that of our own time, but differ in its much greater amount of carbonic acid. It will be remarked that from the affinities which would come into play in the conditions above supposed, all the elements, with the exception of the noble metals, nitrogen, chlorine, the related haloids, and the hydrogen combined with these, would be united with oxygen. The volatility of gold, silver, and platinum, would keep them still in a gaseous condition at temperatures where silicon, and with it the baser metals, were precipitated in the form of oxides.

§ 17. The process just described ceased with the separation from the air of the compounds of sulphur and chlorine, and then commenced the second stage in the action of the atmosphere on the earth's crust, by which, under the influence of carbonic acid and moisture, its complex aluminous silicates are converted into a hydrated silicate of alumina or clay; while the separated lime, magnesia, and alkalies, being changed into bicarbonates, are conveyed to the sea in a state of solution.

The first effect of these dissolved carbonates would be to precipitate the dissolved alumina and the heavy metals, after which came the decomposition of the chloride of calcium and the formation of carbonate of lime and chloride of sodium. This action of carbonic acid is still going on at the earth's surface, slowly breaking down and destroying the hardest rocks, and, aided by mechanical processes, transforming them into clays; although the action, from the comparative rarity of carbonic acid in the atmosphere, is now less energetic than in earlier times, when the abundance of this gas, and a higher temperature, favored the chemical decomposition of the rocks. But now, as then, every clod of clay formed from the decay of a crystalline rock corresponded to an equivalent of carbonic acid abstracted from the atmosphere, and to equivalents of carbonate of lime and common salt formed from the chloride of calcium of the sea-water.

It is very instructive, in this connection, to compare the composition of the waters of the modern ocean with that of the sea in ancient times, whose composition we learn from the fossil sea-waters which are still to be found in certain regions, imprisoned in the pores of the older stratified rocks, and are the source of many of our saline mineral waters*. These are vastly richer in salts of lime and magnesia than those of the present sea, from which have been separated, by chemical processes, all the carbonate of lime of our limestones, with the exception of that derived from the sub-aërial decay of calcareous and magnesian silicates belonging to the primitive crust.

§ 18. The gradual removal, in the form of carbonate of lime, of the carbonic acid from the primeval atmosphere, has been connected with great changes in the organic life of the globe. The air was doubtless at first unfit for the respiration of warm-blooded animals, and we find the higher forms of life coming gradually into existence as we approach the present period of a purer air. Calculations based upon the probable amount of limestone in the earth's crust, lead us to conclude that the amount of carbon thus removed in the form of carbonic acid has been so enormous, that we must suppose the earlier forms of air-breathing animals to have been peculiarly adapted to live in an atmosphere which would probably be too impure to support modern reptilian life.

Growing plants under the stimulus of light possess, as is well known, the power to absorb carbonic acid, appropriating the carbon and liberating oxygen. The importance of this agency in purifying the primitive atmosphere was long since pointed out by Brongniart, and our great stores of fossil fuel have been derived from the decomposition, by the ancient vegetation, of the excess of carbonic acid of the early atmosphere, which, through this agency, was exchanged for oxygen gas. In this connection the vegetation of former periods presents the curious phenomenon of plants allied to those now growing beneath the tropics flourishing within the polar circles. Many ingenious hypotheses have been proposed to account for the warmer climate of earlier times, but are at best unsatisfactory, and it would appear that the true solution of the problem may be found in the constitution of the early atmosphere, when considered in the light of Dr. Tyndal's beautiful researches on radiant heat. He has found that the presence of a few hundredths of carbonic acid gas in the atmosphere, while offering almost no obstacle to the passage of the solar rays, would suffice to prevent almost entirely the loss by radiation of obscure heat.

The aqueous vapor which our atmosphere contains exerts a powerful

* T. S. Hunt. Contributions to the Chemistry of Natural Waters, American Journal of Science, [2.] XXXIX, 184.

influence of the same kind, allowing the sun's rays to reach the earth, but preventing to a great extent the loss by radiation of the heat thus communicated. When, however, the supply of heat from the sun is interrupted at night, the radiation which goes on into space causes the precipitation of a great part of the watery vapor from the air, and the earth, being thus deprived of its protecting shield, becomes more and more rapidly cooled. If now we could suppose the atmosphere to be mingled with some permanent gas which should possess an absorptive power like that of aqueous vapor, this cooling process would be in a great measure arrested, and an effect would be produced similar to that of a screen of glass, which keeps up the temperature beneath it, both directly by preventing the escape of radiant heat, and indirectly by hindering the condensation of the aqueous vapor in the air confined beneath. Such a gas is carbonic acid, and the large amount of it which existed in the atmosphere during former geological periods must have aided greatly to maintain the elevated temperatures which then existed at the earth's surface. Without doubt the greater extent of sea and the absence or rarity of high mountains contributed much to the mild climate of former geologic ages; but to these must be added the influence of the whole of the carbon since condensed in the forms of carbonate of lime and coal, which then existed as a transparent and permanent gas mingled with the atmosphere surrounding the earth, and protecting it like a dome of glass. To this effect of carbonic acid it is possible that other gases may have contributed. The ozone which is mingled with the oxygen set free from growing plants, and the marsh-gas which is now evolved from decomposing vegetation, may, by their absorptive powers, which are far greater than that of carbonic acid, have contributed greatly to maintain a high temperature at the earth's surface in early times.*

§ 19. The part which vegetation has played in the chemical history of the globe has not been limited to the purification of the atmosphere. It seems to have been the great agent through which solar force has effected a partial deoxidation of the thoroughly burned or oxidized materials of the primitive world. By means of growing plants carbonic acid and water are reduced, giving rise to the various forms of carbon and to hydrocarbonaceous bodies, and these have been the agents by which the sulphates of the metals have been deoxidized, and sulphur, native metals, and metallic sulphides produced. It is moreover by the reducing action of decaying organic matters that the peroxide of iron is partially reduced and removed in a soluble form from sediments, to be afterwards deposited in the form of iron ore. The evidences of this reducing and dissolving action of organic matter are met with not only in the fire-clays and iron-stones of the carboniferous system, and among secondary, tertiary, and modern deposits, but on a grand scale in the Laurentian system, where great thicknesses of sediments are found almost destitute of iron, while beds of iron ore more extensive than at any subsequent periods are evidences of the abundance of organic matters at that early time. If these are not more frequently preserved in the form of anthracite and graphite, it is because the amount of peroxide of iron diffused through the sediments of the period furnished the oxygen necessary for the oxidation of the carbon. Inasmuch as the ores of these old rocks, in their present forms of hematite and magnetite, are very insoluble, and represent so much iron withdrawn from the terrestrial circulation, it is evident that the proportion of this element, existing in a dif-

* T. S. Hunt, On the Earth's Climate, etc., American Journal of Science, [2,] xxxvi, 396, 1863.

fused and oxidized state in recent sediments, must be less in those of more remote times.*

To the chemist the presence of graphite, or of a metallic sulphide in a rock, affords clear evidences of the intervention of organic life; and these indirect evidences are met with not only in the oldest known stratified rocks, those of the Laurentian system, but in the eruptive diorites, which rise from beneath them, and are pyritiferous. The presence of graphite, native iron, and sulphurets in most aërolites, not to mention the hydrocarbonaceous matters which they sometimes contain, tells us in unmistakable language that these bodies come from a region where vegetable life has performed a part not unlike that which still plays on our globe, and even lead us to hope for the discovery in them of organic forms which may give us some notion of life in other worlds than our own.

§ 20. Animal life has played in the chemical history of our planet a part much less important than vegetation, since it is entirely dependent for support upon the products elaborated for it by plants, and by chemical forces. Thus, although many limestones are made up chiefly, and even wholly of the calcareous remains of marine animals, these did no more than appropriate from the water the carbonate of lime generated by the chemical actions explained in § 17. If the waters of the present ocean do not deposit carbonate of lime, it is simply because the amount of it now generated by the slow decomposition of the solid rocks is not more than is required for the living organisms which it contains. Let these become extinct and the supply of carbonate of lime, which would still continue, would soon cause deposits of precipitated carbonate of lime. Such a condition of things existing in past ages, in limited basins, has given rise to sediments of this kind, which constitute some of the finest statuary marbles.

The waters charged with the products of the sub-aërial decay of rocks, convey to the sea, as we have seen, bicarbonates of alkalies, lime, and magnesia; but from the reaction of these on the chloride and sulphate of calcium in the ocean waters carbonate of lime alone separates, since bicarbonate of magnesia decomposes chloride of calcium with formation of magnesian chloride. When, however, in a closed sea-basin all of the chloride of calcium is decomposed, the chloride of magnesium is attacked by the alkaline carbonates, and the resulting carbonate of magnesia is separated, mixed with the carbonate of lime which had accompanied these.

When into a similar closed basin, or an evaporating salt lake in a dry region, holding sulphate of magnesia, there is conveyed a water charged with bicarbonate of lime, there results a double decomposition, giving rise to sulphate of lime and bicarbonate of magnesia. The latter, being the more soluble salt, remains dissolved, while the sulphate of lime crystallizes out in the form of gypsum, but at a later period is deposited as a hydrated carbonate of magnesia, generally mixed with carbonate of lime. To effect this reaction it is necessary that there should be present such an excess of carbonic acid as to keep the magnesia in the condition of bicarbonate until the gypsum has crystallized out, inasmuch as dissolved sulphate of lime is readily decomposed by carbonate of magnesia. This condition can only be attained by especial precautions in the atmosphere of our period; but by operating in an atmosphere more highly charged with carbonic acid, the production of gypsum and magnesian carbonate by this reaction is readily effected. We may hence conclude that it was the more highly carbonated atmosphere of early periods which

* Geology of Canada, 1863, p. 573.

favored the accumulation of the great beds of gypsum and magnesian limestones which generally accompany the salt deposits of past geological periods. The hydrated magnesian carbonate, whether the concomitant of gypsum, as in this case, or of chloride of sodium, as in the former reaction, unites chemically with the associated carbonate of lime, and gives rise to dolomite or magnesian limestone.*

§ 21. The action of carbonated alkaline waters on the salts of the sea under ordinary conditions thus gives rise to carbonate of lime, and it is only under peculiar circumstances that magnesian carbonate is separated. The case is, however, changed with silicated alkaline waters coming from deep seated silicated rocks, which undergo a decomposition without the intervention of the atmospheric air, and hold dissolved silicates of alkalies and of lime. These reacting on the magnesian salts dissolved in sea-water give rise to magnesian silicates, which are very insoluble. Hence we frequently find deposits of magnesian silicates in sediments, while silicates of lime are comparatively rare. In the solubility of bicarbonate of magnesia and the insolubility of the corresponding lime salt, and in the insolubility of magnesian silicate and the solubility of silicate of lime, we find a simple explanation of the geological relation of calcareous and magnesian silicates and carbonates.†

§ 22. The relations of the alkalies, potash and soda, require some consideration in this connection. The silico-aluminous compounds of potash possess a much greater degree of stability than those of soda. This is exemplified in the case of rocks which contain, side by side, orthoclase and albite, or oligoclase, when it is often found that the soda-feldspar has undergone decomposition from a loss of a portion of its alkali and partial disintegration, while the orthoclase or potash-feldspar remains unchanged. It is well known that waters holding large portions of potash salts in solution, exchange the potash for soda when filtered through a stratum of earth in which the amount of potash is, nevertheless, as great or greater than the soda; and we find that in natural spring-waters, which often contain considerable amounts of alkaline carbonates, the proportion of potash to the soda is as small as in the ocean. Surface-waters bearing the unfiltered wash of the land carry considerable portions of potash to the sea, but it is constantly removed, partly, at least, by the agency of fucoids, which, as Forchammer has shown, like land-plants, take up large amounts of potash, and subsequently, by their decay in contact with the argillaceous mud, restore the alkali in an insoluble form to the earth. The formation of glauconite, a peculiar silicate rich in potash, which has been going on in the bottom of the sea from a very early period to the present time, has also been constantly withdrawing the potash from the ocean, so that soda is still the predominant base in its waters.

§ 23. The changes of silicated rocks under the influence of water, carbonic acid, and the products of decaying organic matter, present several points of interest. The chemical decomposition of feldspars consists in the removal of their protoxide bases, alkalies, and lime, together with a portion of silica, leaving as a final result a hydrous silicate of alumina or clay. This change is favored by mechanical division, and Daubrée has shown that by the prolonged attrition of the particles of granite under water, the softer and cleavable feldspar is, in great part, reduced to an impalpable powder, while the uncleavable quartz forms rounded grains of sand, the water at the same time dissolving from the feldspar a

* T. S. Hunt, On the Salts of Lime and Magnesia. American Journal of Science, [2,] xlii, 49.

† T. S. Hunt, American Journal of Science, [2,] xl, 49.

certain portion of alkali and silica. The soda-feldspars, being more easily decomposed and disintegrated by atmospheric influences, are broken up by mechanical agencies more readily than the potash-feldspar. The same is true of silicates like hornblende and pyroxene, which are less hard than the feldspars. From the mechanical and chemical disintegration of ordinary crystalline rocks, which consist chiefly of these various minerals, together with quartz, there will result a coarse sandy sediment, in which quartz with more or less orthoclase will prevail, while the finer mud will contain only the more minutely divided particles of these, together with partially decomposed soda-feldspar, clay, and the comminuted hornblende and pyroxene.

§ 24. This process is evidently one which must go on in the wearing away of rocks by aqueous agency, and explains the fact that while quartz, or an excess of combined silica, is, for the most part, wanting in rocks which contain a large portion of alumina, it is generally abundant in those rocks in which potash-feldspar predominates. The coarser and more silicious sediments are readily permeable to infiltrating waters, which gradually remove from them the soda, lime, and magnesia which they still contain, and, if organic matters intervene, the oxide of iron, leaving at last little more than silica, alumina, and potash, the elements of granite, trachyte, gneiss, and mica-schist. On the other hand, the finer sediments, whose origin, simultaneous with the coarser, we have just explained, resisting the penetration of waters, will retain all their soda, lime, magnesia, and iron-oxide, and containing an excess of alumina, with a small amount of silica, may, by their metamorphism, give rise to basic lime and soda-feldspars, and to pyroxene and hornblende—the elements of diorites and dolerites.

§ 25. The disintegration of alkaliferous rocks, however, frequently takes place under such conditions as to be more mechanical than chemical, and it may often happen that sediments still retaining a considerable amount of combined soda become mingled with carbonates of lime and magnesia. The reaction which then goes on between the liberated alkaline silicate and these earthy carbonates gradually effects the conversion of these into silicates, while the alkali is eliminated in the form of soluble carbonate of soda, giving rise to alkaline mineral waters, which, as I have shown, are abundantly generated in sediments where feldspathic matters and earthy carbonates are intermingled. It is only from rocks destitute of these carbonates that silicated alkaline waters can issue.

§ 26. A decomposition more exclusively chemical is observed particularly among the crystalline schists of tropical and semi-tropical regions, where a process of disintegration often destroys the cohesion of the rocks to a considerable depth. This change, which has been but imperfectly studied, is probably dependent in great part on the action of the soluble products of vegetable decomposition, aided by the elevated temperature. It, however, requires careful investigation; and a consideration of the causes which have induced it, and the extent to which it may have in former periods prevailed on the earth's surface, is of great geological importance, since the immense erosion of which geognosy affords us evidence, and which seems so difficult to explain if we conceive the rocks to have been as hard as we now find them in many regions, becomes more easily intelligible if we suppose the cohesion of the crystalline rocks to have been previously much weakened by decay.

§ 27. The operation of the mechanical and chemical agencies which preside over the disintegration of pre-existing rocks naturally divides the insoluble products into two types, approaching in chemical composition, as we have shown, to granites, gneiss, and mica-schist, on the one hand,

and to diorites and dolerites on the other. These correspond to the two classes of igneous rocks designated by Bunsen as the trachytic and pyroxenic types.

§ 28. There is, however, a third source of silicated rocks, to which some allusion has already been made in speaking of the production of magnesian silicates by direct precipitation, as the result of chemical changes in solutions. In this way have been formed, besides these and related protoxide silicates, other silicates, including alumina. This base in certain conditions as yet but imperfectly understood, passes into solution in water, and has given rise to complex silicates, including protoxide bases. As I have elsewhere expressed it, not only steatite, pyroxene, hornblende, and serpentine, but chlorite and, in many cases, garnet and epidote, have had their origin in the crystallization and molecular re-arrangement of natural silicates, generated by chemical processes in aqueous solutions at the earth's surface. To these must be added other silicates, containing alkalies, chiefly potash, such as glauconite, and a hydrous silicate of alumina and potash which has the composition of pinite or agalmatolite and forms beds in the sedimentary rocks of different geological periods. Evidences abound of the solution of alumina, and of the generation, as chemical precipitates, of various aluminiferous silicates. These, like the similarly-formed protoxide silicates, are in most, if not all cases, highly basic, and moreover, from the mechanical conditions of their production and deposition, are found associated and even intermingled with the finely-divided basic sediments of mechanical origin. The aluminous silicates thus formed, though mineralogically important, are probably small in amount when compared with the great mass of argillaceous sediments.

§ 29. The chemical changes which are wrought in the silicated rocks during their mechanical disintegration are, as we have seen, chiefly the elimination of the alkalies, especially the soda, in a soluble form from its aluminous compounds, and the separation and accumulation of the oxide of iron. The decomposition of the silicates of lime and magnesia which takes place is, to a great extent, compensated for by the regeneration of similar compounds by the reaction already explained, but the mean composition of the argillaceous sediments of any geological epoch will depend not only upon the age of a formation, but upon the number of times which its materials have been broken up, and the length of the periods during which they have been exposed, in an unmetamorphosed condition, to the action of water, carbonic acid, and vegetation. If, however, we may assume that this action, other things being equal, has on the whole been most complete in the newest formations, it is evident that the chemical and mineralogical composition of different systems of rocks must vary with their antiquity, so that we may find in their comparative study a guide to their respective ages. Silicious deposits, and chemical precipitates, like the carbonates and silicates of lime and magnesia, may exist, with similar characters, in the geological formations of any age,* not only forming beds apart, but mingled with the less permeable silico-aluminous sediments of mechanical origin. Inasmuch as the chemical agencies giving rise to these compounds were then most active, they may be expected in greatest abundance in the rocks of the earlier periods. In the case of the more permeable and more highly silicious sediments already noticed, (§ 24,) whose principal elements are silica, alumina, and alkalies, the deposits of different ages will be marked chiefly by a progressive diminution in the amount of potash and in the disappearance of the soda which they contain. In the oldest or least

* Geology of Canada, Report, 1866, page 230.

lixiviated rocks the proportion of alkali will be nearly or quite sufficient to form orthoclase or albite with the whole of the alumina present, but as the alkali diminishes, a portion of the alumina will crystallize, upon the metamorphism of the sediments, in the form of a potash-mica, such as muscovite or margarodite. While the oxygen-ratio between the alumina and the alkali in the feldspars just named is 3 : 1, it becomes 6 : 1 in margarodite and 12 : 1 in muscovite. The appearance of these micas in an aluminous rock denotes, then, a diminution in the amount of alkali, until in some strata the feldspar almost entirely disappears, and the rock becomes a quartzose mica-schist. In sediments still further deprived of alkali, metamorphism gives rise to schists filled with crystals of kyanite or of andalusite, simple silicates of alumina, into which alkalies do not enter, at least in noticeable quantities; but, in case the sediment still retains oxide of iron, staurolite and iron-garnet take their place. The matrix of all these minerals is generally a micaceous schist. The last term in this exhaustive process appears to be represented by the disthene and pyrophyllite rocks which occur in some regions of crystalline schists. In conformity with what has just been pointed out, it will be seen that these aluminous silicates destitute of alkalies do not occur in the oldest known sediments; in those of the Laurentian system, in which also mica is found in comparatively small quantities, nearly all the alumina present being in the form of orthoclase or albite.*

§ 30. By metamorphism in geology is understood the change of chemical and mechanical sedimentary deposits into crystalline stratified rocks. The conversion of these sediments into definite mineral species has been effected in two ways: First, by molecular changes—that is to say, by a crystalline arrangement of particles of definite compounds previously formed; and, secondly, by chemical reactions between the elements in heterogeneous sediments, giving rise to new compounds, which become crystalline in their turn. Pseudomorphism, which is the change of one mineral species into another by the introduction or the elimination of some element or elements, presupposes metamorphism, since only definite mineral species can be the subjects of this process. To confound metamorphism with pseudomorphism, as Bischof and others after him have done, is therefore an error. It may be further remarked that although certain pseudomorphic changes may take place in some mineral species existing in veins and near to exposed surfaces, the alteration of great masses of silicated rocks by such a process is as yet an unproved hypothesis.

§ 31. The cases of local metamorphism in proximity to intrusive rocks go far to show, in opposition to the views of certain geologists, that heat has been one of the necessary conditions of the chemical change. The source of this heat is generally admitted to be from below, but to the hypothesis of alteration by ascending heat Naumann has objected that the inferior strata in some cases escape change, and that, in descending, a certain plane limits the metamorphism, separating the altered strata above from the unaltered strata beneath, there being no apparent transition between the two. This, taken in connection with the well-known fact that in many cases the intrusion of igneous rocks causes no apparent change in the adjacent unaltered sediments, shows that heat and moisture are not the only conditions of metamorphism. I showed, by experiments in 1857, that, in addition to these conditions, certain

* For a discussion of this subject see my paper on The Chemical and Mineralogical Relations of Metamorphic Rocks, Dublin Quarterly Journal of Science, July, 1863; also Geology of Canada, 1863, page 561, and chap. XIX, of the same work.

chemical reagents might be necessary, and that water impregnated with alkaline carbonates and silicates would, at a temperature not above 100° centigrade, produce chemical reactions among the elements of many sedimentary rocks, dissolving silica and generating various insoluble silicates.* Subsequent experiments by Daubrée confirmed these results of mine, and both together showed the agency of heated alkaline waters to be sufficient to effect the metamorphism of sediments by the two modes already mentioned, namely, by molecular changes and by chemical reactions.

§ 32. Daubrée further showed, by his observations on the thermal alkaline spring at Plombieres, that its waters, at a temperature of 70° centigrade, had in the course of centuries given rise to the formation of zeolites and other crystalline silicated minerals among the bricks and mortar of the old Roman baths. The influence of similar waters may account for many cases of local metamorphism, but is utterly inadequate to explain the complete and universal alteration of great areas of sedimentary rocks, embracing many hundreds or thousands of square miles. On the other hand, the study of the origin and distribution of mineral springs shows that alkaline waters, whose action in metamorphism I first pointed out, and whose efficient agency Daubrée has since so well shown, are confined to certain sedimentary deposits and to definite stratigraphical horizons, above and below which saline waters wholly different in character are found impregnating the strata. This fact offers a simple solution of the difficulty advanced by Naumann, and a complete explanation of the theory of metamorphism of deeply-buried strata by the agency of ascending heat, which is operative in producing chemical changes only in those strata in which soluble alkaline salts are present.

§ 33. We have said that the metamorphism of sediments includes both hemical and crystallogenic changes. The gradual transformation of amorphous precipitates under water into crystalline aggregates, so often observed in the laboratory, appears to depend upon partial solution and re-deposition of the material, which must not be entirely insoluble in the surrounding liquid. If the solvent power of this be reduced, the dissolved portions are deposited on certain particles rather than others. By a subsequent exaltation of the solvent power of the liquid, solution of a further portion takes place, and this, in its turn, is deposited around the nuclei already formed, which are thus augmented at the expense of the smaller particles, until these at length disappear, being gathered to the crystalline centers. Such a process, which has been studied by H. Deville, suffices, under the influence of the changing temperature of the seasons, to convert many fine precipitates into crystalline aggregates, by the aid of liquids of slight solvent powers. A similar agency may be supposed to have effected the crystallization of buried sediments, and changes in the solvent power of the permeating water might be due either to variations of temperature or of pressure. Simultaneously with this process one of chemical union of heterogeneous elements may go on, and in this way, for example, we may suppose the carbonates of lime and magnesia become united to form dolomite or magnesian limestone. (§ 20.)

§ 34. When the sedimentary strata have thus been rendered crystalline by metamorphism, their permeability to water and their alterability thereby become greatly diminished; and it is only when again broken down by mechanical agencies to the condition of soils and sediments that they once more become subject to the chemical changes which have,

* T. S. Hunt, American Journal of Science, [2,] xxiii, 407; xxv, 287–437.

been described in § 23. While the crystalline stratified rocks are but slightly porous the unaltered strata hold large quantities of water in their pores. The mean of thirty-six determinations upon sandstones, shales, limestones, and dolomites from twenty-five different localities among the unaltered paleozoic sediments of Canada showed that 7.75 volumes of water were held in 100 volumes of the thoroughly-moistened rock. The proportion varied from less than 1.0 per cent. in the more compact limestones, to 10.0 and even 21.0 per cent. in the sandstones, an amount which is greatly exceeded in some more recent limestones.* A large proportion of the ocean's waters is thus imprisoned in the vast volume of unaltered sediments, and set free when these become metamorphosed, a process which is attended with a corresponding reduction of volume. In addition to this, moreover, the clays and other hydrated silicates lose a large part of their chemically-combined water during metamorphism, and become changed into crystalline compounds of increased density. This becomes obvious when we compare the specific gravity of such species as garnet, epidote, chloritoid, staurolite, andalusite and kyanite with that of the unaltered sediments in the midst of which they are generated. From this condensation, then, as well as from the mechanical contraction consequent upon the expulsion of water, the metamorphism of sediments is attended with a very considerable diminution of bulk, which is not without geological significance. It results from the experiments of Sorby (§ 14) that such chemical changes as are accompanied by condensation or diminution of volume are favored and accelerated by pressure, which may thus become a direct agent in promoting metamorphism as well as solution.

§ 35. The crystallization which takes place in sedimentary rocks not unfrequently effaces more or less completely the traces of their stratified and sedimentary origin, as is seen, for example, in many gneisses, which are scarcely distinguishable from granite. The study of such rocks, moreover, affords abundant proof that this alteration has been attended with such a softening that the material has been molded by pressure, forced into fissures or openings in less fusible or less heated strata, and thus taken the form of what is designated as eruptive rocks. The action of heat upon sedimentary rocks is not, however, confined to condensation, crystallization, and softening; strata in which carbonates, sulphates, chlorides, and carbonaceous substances are mingled with silicious and argillaceous matters, will, at a sufficiently-elevated temperature, in the presence of water, undergo such changes as must liberate carbonic acid, hydrochloric acid, and sulphuretted hydrogen, which are the common gaseous accompaniments of volcanic action. From these considerations we are led to a rational theory of volcanic and eruptive rocks, which we conceive to have their seat, not in an uncongealed portion of the once liquid globe, but in the more deeply-buried portions of that disintegrated crust whose origin has been explained in § 14.

§ 36. The history of this theory forms an interesting chapter in geology. As remarked by Humboldt, a notion that volcanic phenomena have their seat in the sedimentary formations, and are dependent on the combustion of organic substances, belongs to the infancy of geology. To this period belong the theories of Lémery and Breislak, (*Cosmos*, v. 443; Otte's translation.) Keferstein, in his *Naturgeschichte des Erdkörpers*, published in 1834, maintained that all crystalline non-stratified rocks, from granite to lava, are products of the transformation of sedimentary strata, in part very recent, and that there is no well-defined

* Geological Report of Canada, 1866, p. 283.—American Journal of Science, [2,] xxxix, 183.

line to be drawn between neptunian and volcanic rocks, since they pass into each other. Volcanic phenomena, according to him, have their origin, not in an igneous fluid center, nor in an oxidizing metallic nucleus, (Davy, Daubeny,) but in known sedimentary formations, where they are the result of a peculiar kind of fermentation, which crystallizes and arranges in new forms the elements of the sedimentary strata, with an evolution of heat as a result of the chemical process. (*Naturgeschichte*, vol. i, p. 109; also *Bulletin de la Société Géologique de France*, [1], vol. vii, p. 197.) In commenting upon these views, (*American Journal of Science*, July, 1860,) I have remarked that, by ignoring the incandescent nucleus as a source of heat, Keferstein has excluded the true exciting cause of the chemical changes which take place in the buried sediments. The notion of a subterranean combustion or fermentation, as a source of heat, is to be rejected as irrational.

§ 37. A view identical with that of Keferstein, as to the seat of volcanic phenomena, was soon after put forth by Sir John Herschel, in a letter to Sir Charles Lyell, in 1836, (*Proceedings of the Geological Society of London*, ii, 548.) Starting from the suggestion of Scrope and Babbage, that the isothermal horizons in the earth's crust must rise as a consequence of the accumulation of sediments, he insisted that deeply-buried strata will thus become crystallized by heat, and may eventually, with their included water, be raised to the melting point, by which process gases would be generated, and earthquakes and volcanic eruptions follow. At the same time the mechanical disturbance of the equilibrium of pressure, consequent upon a transfer of sediments, while the yielding surface reposes on matters partly liquified, will explain the movements of elevation and subsidence of the earth's crust. Herschel was probably ignorant of the extent to which his views had been anticipated by Keferstein; and the suggestions of the one and the other seemed to have passed unnoticed by geologists until, in March, 1858, I reproduced them in a paper read before the Canadian Institute, (Toronto,) being at that time acquainted with Herschel's letter, but not having met with the writings of Keferstein. I there considered the reactions which would take place under the influence of a high temperature in sediments permeated with water, and containing, besides silicious and aluminous matters, carbonates, sulphates, chlorides, and carbonaceous substances. From these, it was shown, might be produced all the gaseous emanations of volcanic districts, while from aqueo-igneous fusion of the various admixtures might result the great variety of eruptive rocks. To quote the words of my paper just referred to: "We conceive that the earth's solid crust of anhydrous and primitive igneous rock is everywhere deeply concealed beneath its own ruins, which form a great mass of sedimentary strata, permeated by water. As heat from beneath invades these sediments, it produces in them that change which constitutes normal metamorphism. These rocks, at a sufficient depth, are necessarily in a state of igneo-aqueous fusion; and in the event of fracture in the overlying strata, may rise among them, taking the form of eruptive rocks. When the nature of the sediments is such as generate great amounts of elastic fluids by their fusion, earthquakes and volcanic eruptions may result, and these—other things being equal—will be most likely to occur under the more recent formations." (*Canadian Journal*, May, 1858, vol. iii, p. 207.)

§ 38. The same views are insisted upon in a paper "On some points in Chemical Geology." (Quarterly Journal of the Geological Society, London, November, 1859, vol. xv, page 594,) and have since been repeatedly put forward by me, with further explanations as to what I have designated

above, *the ruins of the crust of anhydrous and primitive igneous rock*. This, it is conceived, must, by contraction in cooling, have become porous and permeable, for a considerable depth, to the waters afterward precipitated upon its surface. In this way it was prepared alike for mechanical disintegration, and for the chemical action of the acids, which, as shown in § 16, must have been present in the air and the waters of the time. It is, moreover, not improbable that a yet unsolidified sheet of molten matter may then have existed beneath the earth's crust, and may have intervened in the volcanic phenomena of that early period, contributing, by its extravasation, to swell the vast amount of mineral matter then brought within aqueous and atmospheric influences. The earth, air, and water thus made to react upon each other, constitute the first matter from which, by mechanical and chemical transformations, the whole mineral world known to us has been produced.

§ 39. It is the lower portions of this great disintegrated and water-impregnated mass which form, according to the present hypothesis, the semi-liquid layer supposed to intervene between the outer solid crust and the inner solid and anhydrous nucleus. In order to obtain a correct notion of the condition of this mass, both in earlier and later times, two points must be especially considered, the relation of temperature to depth, and that of solubility to pressure. It being conceded that the increase of temperature in descending in the earth's crust is due to the transmission and escape of heat from the interior, Mr. Hopkins showed mathematically that there exists a constant proportion between the effect of internal heat at the surface and the rate at which the temperature increases in descending. Thus, at the present time, while the mean temperature at the earth's surface is augmented only about one-twentieth of a degree Fahrenheit, by the escape of heat from below, the increase is found to be equal to about one degree for each sixty feet in depth. If, however, we go back to a period in the history of our globe when the heat passing upwards through its crust was sufficient to raise the superficial temperature twenty times as much as at present, that is to say, one degree of Fahrenheit, the augmentation of heat in descending would be twenty times as great as now, or one degree for each three feet in depth. (*Geological Journal*, viii, 59.) The conclusion is inevitable that a condition of things must have existed during long periods in the history of the cooling globe when the accumulation of comparatively thin layers of sediment would have been sufficient to give rise to all the phenomena of metamorphism, vulcanicity, and movements of the crust, whose origin Herschel has so well explained.

§ 40. Coming, in the next place, to consider the influence of pressure upon the buried materials derived from the mechanical and chemical disintegration of the primitive crust, we find that by the presence of heated water throughout them, they are placed under conditions very unlike those of the original cooling mass. While pressure raises the fusing point of such bodies as expand in passing into the liquid state, it depresses that point for those which, like ice, contract in becoming liquid. The same principle extends to that liquefaction which constitutes solution; where, as is with few exceptions the case, the process is attended with condensation or diminution of volume, pressure will, as shown by the experiments of Sorby, augment the solvent power of the liquid. Under the influence of the elevated temperature, and the great pressure which prevail at considerable depths, sediments should, therefore, by the effect of the water which they contain, acquire a certain degree of liquidity, rendering not improbable the suggestion of Scheerer, that the presence of five or ten per cent. of water may suffice, at temperatures approaching red-

ness, to give to a granitic mass a liquidity partaking at once of the character of an igneous and an aqueous fusion. The studies by Mr. Sorby of the cavities in crystals have led him to conclude that the constituents of granitic and trachytic rocks have crystallized in the presence of liquid water, under great pressure, at temperatures not above redness, and consequently very far below that required for simple igneous fusion. The intervention of water in giving liquidity to lavas, has, in fact, long been taught by Scrope, and notwithstanding the opposition of plutonists like Durocher, Fournet, and Rivière, is now very generally admitted. In this connection, the reader is referred to the *Geological Magazine* for February, 1868, page 57, where the history of this question is discussed.

§ 41. It may here be remarked that if we regard the liquefaction of heated rocks under great pressure, and in presence of water, as a process of solution rather than of fusion, it would follow that diminution of pressure, as supposed by Mr. Scrope, would cause not liquefaction, but the reverse. The mechanical pressure of great accumulations of sediment is to be regarded as co-operating with heat to augment the solvent action of the water, and as being thus one of the efficient causes of the liquefaction of deeply-buried sedimentary rocks.

§ 42. That water intervenes not only in the phenomena of volcanic eruptions, but in the crystallization of the minerals of eruptive rocks, which have been formed at temperatures far below that of igneous fusion, is a fact not easily reconciled with either the first or the second hypothesis of volcanic action, but is in perfect accordance with the one here maintained, which is also strongly supported by the study of the chemical composition of igneous rocks. These are generally referred to two great divisions, corresponding to what have been designated the trachytic and pyroxenic types, (§ 27,) and to account for their origin, a separation of a liquid igneous mass beneath the earth's crust into two layers of acid and basic silicates was imagined by Phillips, Durocher, and Bunsen. The latter, as is well known, has calculated the normal composition of these supposed trachytic and pyroxenic magmas, and conceives that from them, either separately or by admixture, the various eruptive rocks are derived; so that the amounts of alumina, lime, magnesia, and alkalies sustain a constant relation to the silica in the rock. If, however, we examine the analyses of the eruptive rocks in Hungary and Armenia, made by Streng, and put forward in support of this view, there will be found such discrepancies between the actual and the calculated results as to throw grave doubts on Bunsen's hypothesis.

§ 43. Two things become apparent from a study of the chemical nature of eruptive rocks: first, that their composition presents such variations as are irreconcilable with the simple origin generally assigned to them; and second, that it is similar to that of sedimentary rocks whose history and origin it is, in most cases, not difficult to trace. We have already pointed out (§ 27) how the natural operation of mechanical and chemical agencies tends to produce among sediments a separation into two classes, corresponding to the two great divisions above noticed. From the mode of their accumulation, however, great variations must exist in the composition of the sediments, corresponding to many of the varieties presented by eruptive rocks. The careful study of stratified rocks of aqueous origin discloses, in addition to these, the existence of deposits of basic silicates of peculiar types. Some of these are in great part magnesian; others consist of compounds like anorthite and labradorite, highly aluminous basic silicates, into which lime and soda enter, to the almost complete exclusion of magnesia and other bases; while in the masses of pinite or agalmatolite rock we have a similar aluminous

silicate, in which lime and magnesia are wanting, and potash is the predominant alkali, (§ 28.) In such sediments as these just enumerated we find the representatives of eruptive rocks like peridotite, phonolite, leucitophyre, and similar rocks, which are so many exceptions in the basic group of Bunsen. As, however, they are represented in the sediments of the earth's crust, their appearance as exotic rocks, consequent upon a softening and extravasation of the more easy liquefiable strata of deeply buried formations, is readily and simply explained.

§ 44. In this connection a few words may be said about the popular notion which makes granite the substratum of all stratified formations, and even identifies it with the supposed primitive crust of the globe. That this crust is everywhere concealed beneath its own ruins, and, moreover, that its composition must have been very different from granite, we have endeavored to explain, (§ 16.) The Laurentian, the oldest known system of rocks, includes in its vast volume great interstratified masses of gneiss, often closely resembling granite, and it is extremely probable that these, softened and extravasated, may form the eruptive granites which break through more recent systems of strata. These granitic gneisses are, however, clearly stratified, and hold, moreover, intercalated beds of quartzite and of limestone, often of great volume, and including the remains of an animal organism—the *Eozoon Canadense*. The predominance of feldspar, which gives the granitic character to the aluminous rocks of early periods, has already been explained in § 29 as resulting from the great abundance of combined alkalies in these ancient rocks. The presence of quartz, an essential element alike in gneiss and granite, would suffice to show that granite is in all cases a secondary or derived rock, formed under aqueous influences—even had Sorby not shown that the minute crystal-cavities in the quartz of granitic rocks contain liquid water which must have been introduced at the time of crystallization. Quartz has not only never been met with as a result of igneous fusion, but it is clearly shown by the experiments of Rose that a heat even much less than that required for the fusion of quartz destroys it, changing it into a new substance, which differs both in chemical and physical properties from quartz. We have pointed out in § 16 the chemical process by which it may be supposed that silica was set free from the primitive silicated mass, under conditions which would permit its conversion into quartz.

§ 45. The rocks mentioned in preceding sections are, as regards their geognostical relations, divided into stratified or indigenous and erupted or exotic rocks, the latter being looked upon as the results of the softening and displacement of the former. Besides these, it is necessary to distinguish a third kind of rock-masses, which, like the latter, occupy fissures in previously-formed rocks, but are unlike them in origin, and have been deposited from aqueous solutions. The most familiar form of these is met with in the vein-stones of quartz, calcite, barytine, and fluor, which are often the gangue of metallic ores. A careful study of the various kinds of veins and their relations leads us, however, to admit that almost all the mineral species which occur in the preceding classes of rocks may exist in vein-stones, which, from the mode of their production, we have designated endogenous rocks. Calcareous veins in the Laurentian rocks may contain all the mineral species of indigenous limestones, and quartzo-feldspathic veins are made up of aggregates which are familiarly designated as granites. To these, in fact, belong all those so-called granitic veins which are marked by containing fine crystallizations or rare mineral species. When, as is often the case, these marks

52702

are wanting it is sometimes difficult to distinguish in hand-specimens between indigenous, exotic, and endogenous granites.

§ 46. The deposition of these mineral species from solution has doubtless taken place under considerable degrees of heat and pressure, which could only exist at great depths in the earth's crust. Waters charged with mineral elements by percolation through deeply-seated strata rise through fissures in these and deposit along the channels their dissolved matters, a process not so much the result of cooling as of that decrease of solvent power which must follow the diminution of pressure in accordance with Sorby's conclusions.*

§ 47. As pointed out in § 17, the first precipitates from the water of the primeval sea must have contained oxidized compounds of most of the heavy metals. These early deposits, by mechanical division or by solution, became subsequently diffused, and entered into the composition of later sedimentary strata. Removed from these by watery solution, the metallic compounds have been, in different ages, brought to the surface to be deposited in some cases as oxides or carbonates, or reduced by the action of organic matters to the state of sulphurets or native metals, and mingled with the contemporaneous sediments in beds or in disseminated grains. During the subsequent alteration of the strata, these metallic matters, being taken into solution, have been re-deposited in fissures in the metalliferous strata, forming veins, or, ascending to higher beds, have given rise to metal-bearing veins in strata not themselves metalliferous. The metals of the sedimentary rocks are now, however, for the greater part, in the form of insoluble sulphurets, so that we have only traces of them in a few mineral springs, which serve to give a faint notion of the agencies at one time at work in the sediments and waters of the earth's crust. Like the iron, (§ 19) these metals have been in great part withdrawn from the terrestrial circulation. The frequent occurrence of these metals in waters which are alkaline from the presence of carbonate of soda, is significant, when taken in connection with the metalliferous character of certain dolomites, which probably owe their origin to the action of similar alkaline springs upon basins of sea-water, (§ 20.) The intervention of intense heat and fusion or sublimation to explain the origin of metallic ores is uncalled for. The solvent powers of water and of various saline, alkaline, and sulphuretted solutions at high temperatures, in connection with the notions above enunciated, will suffice to form the basis of a rational theory of metallic deposits.†

§ 48. The consideration of the nature and origin of endogenous rocks has led to a digression to discuss the theory of metalliferous veins, which the plan of this essay did not permit us to treat before. We now resume the line of inquiry followed from § 36 to § 43, and proceed to consider the phenomena of volanoes and earthquakes in accordance with the notions already put forward.

Violent movements of the earth's crust are confined to certain regions of the globe, which are at the same time characterized by volcanic

* Of this a remarkable example was afforded in 1866 at Goderich, in Ontario, where, at a depth of 1,000 feet, a bed of rock-salt was met, from which for a time a saturated or rather supersaturated brine was obtained. As an evidence of this, I saw a cube of pure salt, one fourth of an inch in diameter, which had formed upon and around a projecting point of an iron valve in the pump, above the surface of the ground. The liquid beneath a pressure of 1,000 feet of brine, equal to about 1,200 feet of water, or 36 atmospheres, having taken up more salt than it could hold at the ordinary pressure, deposited a portion of it as it reached the surface, and actually obstructed thereby the action of the pump. After a few months of pumping, however, the well ceased to afford a fully saturated brine.

† American Journal of Science, [2,] xxxi, 405, and xl, 213.

activity; from which it is reasonably inferred that the phenomena of earthquakes and volcanoes have a common origin. The discharge through openings in the earth's crust, of ignited stony matter, generally in a fused condition, and the disengagement of various gases and vapors, accompanied by movements of elevation or subsidence of considerable areas of the earth's surface, sometimes rapid and paroxysmal, and attended with great vibratory movements, are evidences of a yielding crust of solid rock resting upon an igneous and fluid mass below. To the same conditions are also to be ascribed the slow movements of portions of the earth's surface, shown in the rise and fall of continents in regions remote from centers of volcanic activity. The unequal tension of the yielding crust and the sudden giving way of the overstrained portions are probably the immediate cause of earthquake phenomena; the seat of these, according to the deductions of Mallet, is to be found at depths of from seven to thirty miles from the surface.

§ 49. A brief description of the phenomena of volcanoes will here be necessary. Volcanoes are openings in the earth's crust through which are discharged solid, liquid, and gaseous matters, generally in an intensely heated condition. Sometimes the ejected material is solid, and consists of broken, comminuted rock, or the so-called volcanic ashes. Oftener, however, it is discharged in a more or less completely fused condition, constituting lava, which is sometimes fluid and glassy, but more frequently pasty and viscid, so that it flows slowly and with difficulty. The ejected materials, whether liquid or solid, build up volcanic cones by successive layers—a fact which has been established by modern observers in opposition to the notion come down from antiquity, that volcanic hills are produced by an uprising or tumefaction of previously horizontal layers of rock by the action of a force from beneath. First among the gaseous products of volcanoes is watery vapor; water appears not only to be involved in all volcanic eruptions, but to be intimately combined with the lavas, to which, as Scrope has shown; it helps to give liquidity. The water at this high temperature is retained in combination under great pressure, but as this pressure is removed passes into the state of vapor, a process which explains the swelling up of lavas and their rise in the craters of the volcanoes. Besides watery vapor, carbonic and hydrochloric acid gases, and hydrogen, both free and combined with sulphur and with carbon, are products of volcanoes. The combustion of the inflammable gases in contact with air sometimes give rise to true burning mountains—a name which does not properly belong to such as give out only acid gases, steam, and incandescent rocky matters, which are incombustible.

§ 50. The escape of elastic fluids from lavas gives to them a cellular structure, but when slowly cooled under pressure, as seen in the dykes traversing the flanks of volcanoes, the stony materials assume a more solid and crystalline condition, and resemble the older eruptive rocks found in regions not now volcanic. These include granites, trachytes, dolerites, basalts, &c., and are masses of rock which, though extravasated after the manner of lavas, became consolidated in the midst of surrounding rocks, and consequently under considerable pressure, (§ 37.) Their presence marks either the lower portions of volcanoes whose cones have been removed by denudation, or outbursts of liquefied rock which never reached the surface. The escape of such matters, and the formation of volcanic vents, are but accidents in the history of the igneous action going on beneath the earth's surface. We shall, therefore, regard the extravasation of igneous matter, whether as lava or ashes at the surface, or as plutonic rock in the midst of strata, as, in its

wider sense, a manifestation of vulcanicity, and for the elucidation of our subject consider both those regions characterized by great outbursts of plutonic rock in former geologic periods and those now the seats of volcanic activity, which, in these cases, can generally be traced back some distance into the tertiary epoch. To begin with the latter, the first and most important is the great continental region which may be described as including the Mediterranean and Aralo-Caspian basins, extending from the Iberian Peninsula eastward to the Thian-Chan Mountains of Central Asia. In this great belt, extending over about ninety degrees of longitude, are included all the historic volcanoes of the ancient world, to which we must add the extinct volcanoes of Murcia, Catalonia, Auvergne, the Vivarais, the Eifel, Hungary, &c., some of which have probably been active during the human period.*

Besides the great region just indicated, must be mentioned that of our own Pacific slope, from Fuegia to Alaska, from whence, along the eastern shore of Asia, a line of volcanic activity extends to the terrible burning mountains of the Indian archipelago. Volcanic islands are widely scattered over the Pacific basin, and volcanoes burn amid the thick-ribbed ice of the Antarctic continent. The Atlantic area is in like manner marked by volcanic islands from Jan Mayen and Iceland to the Canaries, the Azores, and the Caribbean Islands, and southward to Ascension, St. Helena, and Tristan d'Acunha.

§ 51. The continents, with the exception of the two areas already defined, present no evidences of modern volcanic action, and the regions of ancient volcanic activity, as shown by the presence of great outbursts of eruptive rocks, are not less limited and circumscribed. In northern Europe the chain of the Urals, an area in central Germany, and one in the British Islands are apparent, and in North America there appear to have been but two volcanic regions in the paleozoic period—one in the basin of Lake Superior, and another, which may be described as occurring along either side of the Appalachian chain to the northeast, including the valleys of the lower St. Lawrence, Lake Champlain, the Hudson and Connecticut Rivers, and extending still further southward. The study of the various eruptive rocks of this region shows that volcanic activity in different parts of it was prolonged from the beginning of the paleozoic period till after its close.

§ 52. The theory of Keferstein and Herschel, explained in § 37, shows in what manner volcanic phenomena may be directly dependent on the accumulation of sedimentary strata. It has already been shown that both temperature and pressure combine to produce in the lower portions

* It is a most significant fact that this region is nearly co-extensive with that occupied for ages by the great civilizing races of the world. From the plateau of Central Asia, throughout their westward migration to the pillars of Hercules, the Indo-European nations were familiar with the volcano and the earthquake; and that the Semitic race were not strangers to the same phenomena, the whole poetic imagery of the Hebrew Scriptures bears ample evidence. In the language of their writers, the mountains are molten, they quake and fall down at the presence of the Deity, when the melting fire burneth. The fury of His wrath is poured forth like fire; He toucheth the hills and they smoke; while fire and sulphur come down to destroy the doomed cities of the plain, whose foundation is a molten flood. Not less does the poetry and the mythology of Greece and Rome bear the impress of the nether realm of fire in which the volcano and the earthquake have their seat, and their influence is conspicuous throughout the imaginative literature and the religious systems of the Indo-European nations, whose contact with these terrible manifestations of unseen forces beyond their foresight or control could not fail to act strongly on their moral and intellectual development, which would have doubtless presented very different phases had the early home of these races been the Australian or the eastern side of the American continent, where volcanoes are unknown and the earthquake is scarcely felt. (From a lecture before the Amer. Geographical Society, April, 1869.)

of the sedimentary material a condition of igneo-aqueous fusion. It would be foreign to our plan to discuss in this place the agencies which, from early geologic periods, have been effecting the transfer of sediments, alternately wasting and building-up continents. One, however, requires notice in this connection, namely, the contraction of sediments consequent upon chemical changes, as already explained in § 34, which must result in subsidence. Such an effect may also result from the extravasation of great volumes of liquefied rock, and in either case the depressed portion of the surface becomes a basin, in which sediments may subsequently accumulate, and by their weight upon the yielding stratum beneath continue the process of subsidence. While the lower and more fusible strata becomes softened, the great mass of the more silicious rocks, losing their porosity, become cemented into a comparatively rigid mass, and finally, as a result of the earth's contraction, or to counterbalance the depression of some other region, are uplifted as a hardened and corrugated continental mass, from whose irregular erosion results a mountainous region.*

§ 53. Those strata which, from their composition, yield, under the conditions just described, the most liquid products, are, it is conceived, the source of all plutonic and volcanic rocks. Accompanied by water, and by difficultly coercible gases, they are either forced among the fissures which form in the overlying strata, or find their way to the surface. The variations in the composition of lavas and their accompanying gases in different regions, and even from the same vent at different times, are strong confirmations of the truth of this view. As explained in § 39, the semi-liquid layer of water-impregnated material constitutes a plastic bed, upon which the stratified sediments repose. These, by their irregular distribution over different portions of the earth, determined, after a lapse of time, in the regions of their greatest accumulation, volcanic and plutonic phenomena. It now remains to show the observed relation of these phenomena, both in the earlier and later times, to great accumulations of sediment.

§ 54. If we look at the North American continent, we find along its northeastern portion evidences of great subsidence and an accumulation of not less than 40,000 feet of sediment along the line of the Appalachians from the Gulf of St. Lawrence southward, during the paleozoic period, and chiefly, it would appear, during its earlier and later portions. This region is precisely that characterized by considerable eruptions of plutonic rocks during this period, and for some time after its close. To the westward of the Appalachians, the deposits of paleozoic sediments were much thinner, and in the Mississippi valley are probably less than 4,000 feet in thickness. Conformably with this, there are no traces of plutonic or volcanic outbursts from the northeast region just mentioned throughout this vast paleozoic basin, with the exception of the region of Lake Superior, where we find the early portion of the paleozoic age marked by a great accumulation of sediments, comparable to that occurring at the same time in the region of New England, and followed or accompanied by similar plutonic phenomena. Across the plains of northern Russia and Scandinavia, as in the Mississippi valley, the paleozoic period was represented by not more than 2,000 feet of sediments, which still lie undisturbed, while in the British Islands 50,000 feet of paleozoic strata, contorted and accompanied by igneous rocks,

* For a discussion of this subject and the theory of mountains, including the views of Professor James Hall, see the author on *American Geology*, American Journal of Science, [2] xxi, 406.

attest the connection between great accumulation and plutonic phenomena.

§ 55. Coming now to modern volcanoes, we find them in their greatest activity in oceanic regions, where subsidence and accumulation are still going on. Of the two continental regions already pointed out, that along the Mediterranean basin is marked by an accumulation of mesozoic and tertiary sediments, 20,000 feet or more in thickness. It is evident that the great mountain zone, which includes the Pyrenees, the Alps, the Caucasus and the Himalayah, was, during the later secondary and tertiary periods, a basin in which vast accumulations of sediments were taking place, as in the Appalachian belt during the paleozoic times. Turning now to the other continental region, the American Pacific slope, similar evidences of great accumulations during the same periods are found throughout its whole extent, showing that the great Pacific mountain belt of North and South America, with its attendant volcanoes, is, in the main, the geological equivalent or counterpart of the great east and west belt of the eastern world.

It is to be remarked that the volcanic vents are seldom immediately along the lines of greatest accumulation, but appear around and at certain distances therefrom. The question of the duration of volcanic activity in a given region is one of great interest, which cannot, for want of time, be considered here. It appears probable that the great manifestations of volcanic force belong to the period of depression of the area of sedimentation, if we may judge from the energy and copiousness of the eruptions of island volcanoes, although the activity is still prolonged after the period of elevation.

As regards the geological importance of volcanic and earthquake phenomena, their significance is but local and accidental. Volcanoes and earthquakes are and always have been confined to limited areas of the earth's surface, and the products of volcanic action make up but a small portion of the solid crust of the globe. Great mountains and mountain chains are not volcanic either in their nature or their origin, though sometimes crowned by volcanic cones; nor are earthquakes and volcanoes to be looked upon as anything more than incidental attendants upon the great agencies which are slowly but constantly raising and depressing continents.

00052702

V

Digitized with financial assistance from the
Government of Maharashtra
on 13 February, 2016